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# Engineering News-Record

Sewer Cleaning Crew at Ocean Outfall, Santa Barbara, Calif.

May 29, 1930

## Backwater Gates in Connors Creek Sewer at Detroit

By Milton F. Wagnitz

## Building a Wet-Process Cement Plant in Texas

By Terrell Bartlett

## Highway Fills Across Louisiana Swamps

By H. B. Henderlite and John J. Mundinger

## Proportioning 400,000 Yards of Concrete for New York Port Authority Bridges

By A. W. Munsell

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DEVOTED TO CIVIL ENGINEERING AND CONTRACTING

F. E. SCHMITT, *Editor*

Volume 104 NEW YORK, MAY 29, 1930 Number 22

## *Growing Industrial Research*

LARGE-SCALE research has performed marvels for the advance and prosperity of industry, but it promises to do still more in the future, since every new development opens up more questions than it puts to rest. This course of events is so characteristic of recent industrial growth that it exerts a steady pressure toward fuller evolution of research facilities. A remarkable demonstration of the trend may be seen in the magnificent research laboratory built during the past year at the New Kensington plant of the Aluminum Company of America. The institution is the direct response to the proved needs of necessary research work that grew up in the plant itself but finally found facilities there so inadequate that an ample laboratory, specially planned, and placed in clean and quiet surroundings, was a natural development. The decision to build it will soon justify itself. Though only just occupied by its staff, it is already busy with studies that open up new prospects at every turn—in metallurgy, in structural investigations, in chemical, corrosion and furnace problems, among others. Its establishment furnishes striking proof that the course of industrial research continues strongly upward.

## *Taking Chances*

BLAME for the framework collapse of a bakery building in New York while in course of erection, noted in the news pages of this issue, must in the final analysis rest upon the entire building industry, which has permitted these composite-column structures to be erected in a practically unbraced condition. One or two lines of loosely connected struts would not be considered adequate in a steel-frame building if columns were erected in such extreme lengths as 65 feet. Why is such bracing regarded as safe for the steel cores of a reinforced-concrete building? Unfortunately for the designers and erectors of the Gottfried Building, their structure was the one that had to collapse to draw attention to the unsafe practice. Only in so far as they were following a practice sanctioned by precedent and by lack of censure on the part of city building departments in New York and elsewhere can those in charge of this building be blamed. They took only the same chances that others had taken before them. But they were chances, nevertheless, and these engineers lost where others had been lucky. Obviously there is something basically wrong with the bracing of a structure when a local disturbance such as the toppling of a derrick boom will drag practically every column on a half-acre site to the ground. Instead of acting as braces, the 6-in. temporary struts, following the collapse of one or two of the columns, served as the agency for spreading destruction over the entire structure. It can only be hoped that this tragic failure will serve to initiate a radical revision in the bracing used in connection with structural steel column cores. For until at least one level of concrete floor is in place the safety of these structures depends entirely upon the efficacy of the permanent and temporary bracing. Struts above or below every floor level should be a building department requirement, and adequate anchorage of columns and foundations should be a prime requisite in every design. The cost of the additional steel required to assure the safety of composite-column concrete buildings during erection is insignificant compared with the loss of life and property that may result from inadequate bracing.

## *Meeting a Need*

TIMELY, indeed, was the action of the citizens of Los Angeles last week in voting the bond issue so urgently needed to take care of immediate additions to the city water-supply system. With one-half the flow of the aqueduct from Owens Valley coming from wells whose operation was threatened by injunction from ranchers because of lowering water levels, and with a surface supply decidedly subnormal because of a continued deficiency in the precipitation, a water shortage was imminent. Relief provided by the bond issue includes the purchase of towns, riparian land, and water rights, to give the city complete control over the water supply in the valley. In addition, money is made available for improved facilities, particularly increased terminal storage. The present danger of serious water shortage has been averted and a supply for the next few years is assured. Another important effect flows from this action, one which concerns the future of the whole territory: It will now be possible for engineers and public officials charged with the duty of maintaining an adequate water supply in the face of rapidly increasing needs to transfer all of their energy and activity to the larger task of planning the ultimate Colorado River supply.

## *A Long Step Forward*

RAILROADS entering New York City have accepted the Port Authority's plan for the construction of the first of three great inland union terminals. This is a notable step in reducing railroad terminal costs. It is none the less notable as a major movement toward relief of street traffic congestion through a reduction in light-loaded truck movements and in truck travel. Time saving for both truck and shipment is another important factor. At present there is much lost time in truck travel between railroad freight houses in the collection and delivery of freight. From another point of view the construction of these inland terminals will be advantageous in releasing much waterfront property for more essentially marine purposes, most railroads having maintained freight houses at the river piers where merchandise could be brought in and taken away by car float or lighter. Major changes in policy and methods are not easily brought about, especially those requiring co-operation on the part

of such naturally competitive organizations as are railroad companies. The railroads are to be congratulated upon having gone into this plan for the common good, and the Port Authority is to be commended for its persistent effort in bringing the agreement about.

## *Across the Continent*

TRANSFER of control of the Missouri Pacific Railway to the Van Sweringen interests again revives the question of the need for a transcontinental railway in this country. Control of the Missouri Pacific, which carries with it a half interest in the Denver & Rio Grande Western, pushes the western limit of the roads under single control to Salt Lake City. Only the Western Pacific is needed to create a system reaching from New York and Newport News to San Francisco on the West Coast and to New Orleans on the Gulf, a system great enough to have satisfied the fondest hopes of the great railroad builders of earlier days. And the Interstate Commerce Commission plan of railroad consolidation assigns the Western Pacific to the Missouri Pacific system. Whether the I.C.C. will continue to look with favor upon such an affiliation so long as the Missouri Pacific continues in its present relation to the Chesapeake & Ohio-Erie system of the Van Sweringens is another question. It will depend upon whether the I.C.C. can be convinced of the need for a transcontinental system. As idealistic dreams such systems have great possibilities; as operating propositions they have fewer attractions. Diversification of business is given by the commission as its reason for spreading out some of the systems which it proposes to set up, but the need for such wide diversification as would occur with the proposed system is not apparent. Nor is there any apparent reason for a transcontinental system to move freight and passenger trains from coast to coast. Freight now moves from coast to coast in as complete trains as would move over one system, and passenger trains could be so moved if the demand were sufficiently great. The Canadian roads run transcontinental trains, but their systems are divided into great operating units which are practically independent. The Western Pacific prefers to maintain its independence so that it can deal on equal terms with all the roads with which it connects. Until some compelling need for a transcontinental system can be shown it is doubtful whether the Interstate Commerce Commission will bring pressure to bear upon it to give up its independence and become part of a transcontinental system.

## *Outfall Sewer Joints Again*

ANOTHER case of extensive repair work on the joints of a concrete outfall sewer again calls attention to the weak point in this type of construction. Outfalls are satisfactory only while the sections are intact and all the sewage is delivered to the outlet. Laid on the ocean floor, or, little better, in a trench, subject to the surge and suction of wave action on its foundation, they are exposed to almost inevitable settlement and displacement. Joints that do not provide for these movements are bound to open. Past experience on the Hyperion outfall sewer of Los Angeles and the recent repair work required on the Santa Barbara outfall, described elsewhere in this issue, indicate that the problem of joint design for such structures needs study to eliminate costly reconstruction work soon after completion. An outfall which cannot be depended upon is a poor piece of municipal equipment.

## *In the Public Interest*

CAN expert engineering counsel be dealt with as a commodity and be made the subject of competitive bidding? This question, long a sore issue in civil engineering practice, is brought to the front in sensational form through the recent Lima bidding. Its answer hinges on the public interest involved, not primarily on abstract concepts of professional propriety or rules of ethics, for such rules are tenable only as they express what the public interest demands.

A good many years ago professional engineering practice was guided by certain principles safeguarding the independence and disinterestedness of the service rendered. It was held that the engineer should not seek the client, but the client should seek the engineer—just as the lawyer would not solicit a client, or the doctor a patient. Not only was the hawking-about of professional service considered improper but competitive rivalry for engagements was also taboo. The professional man would not attempt to displace another from an engagement, as by claiming superior ability or by asking a smaller fee. And the client, let us say a city, did not ask engineers to bid on planning its water or sewerage works.

That was in the old days. Matters have become somewhat different, at least in civil engineering practice. Engineers have grown more numerous. There is more work to be done, and clients are not well informed as to available engineers, their experience and ability. It is more difficult for the client to select the engineer best suited to his needs. Whether because of these changes or for other reasons, solicitation of engagements is common. Often a client—usually a city or similar public authority—requests various engineers to indicate their charges and their qualifications before selecting one of them. Whether engineers under these circumstances ever descend into plain self-laudation can only be guessed; some, no doubt, are tempted in this direction.

In all these changes, the professional activity of devoting specialized skill, judgment and experience to the service of a client is progressively transformed to the business activity of merchandising a commodity. This has not yet happened in the medical and legal professions, where ambulance chasing is still rated improper—in fact, is subject to prosecution and severe penalty. In architecture it is said to be not unknown. There are differences among these several fields of practice, of course, which vitiate any direct comparison; but the professions are alike in depending on a relation of trust between client and adviser which precludes anything other than high-principled, non-mercenary co-operation as a basis for success.

Reducing engineering service to a trade commodity reaches unmistakably definite expression in formal advertisement for competitive engineering-service bids. The Lima case, not the first or only one, raises the issue in exceptionally clear-cut form. Is such bidding in the public interest? Let us consider the facts.

Two months ago the city of Lima, Ohio, published an advertisement calling for bids from engineers for their planning and advisory service in the construction of a sewage-disposal plant and a scheme of river-channel regulation. More than a dozen engineering firms submitted bids. The figures of the official summary, given in our pages of Unit Prices four weeks ago, are as definite as the figures of contractors bidding to supply certain materials or carry out a certain construction job. But they

have less meaning. They do not imply that the public will receive the same return whoever may be victorious in this competition.

The first principle of competitive bidding is that the system cannot be applied unless the proposed exchange between the two parties—money for goods or for service performance—is capable of definite measurement. So and so many tons of coal may be bid for, on the basis of size, heat value, time and method of delivery. Or, again, construction of a sewer or of a city hall may be bid for on the basis of drawings and specifications which define the material, work and time. The engineering services which Lima sought to engage are not subject to similar specification. There is nothing to measure the performance. Nothing will assure the city of receiving equivalent or even reasonably similar service from different bidders.

As a result, the Lima bids are in no sense comparable. They are for this reason not competitive, since the figure of each bidder represents certain services that he proposes to render to the city, which are likely to be quite different from those contemplated by another bidder or those desired or needed by the city. In short, the bids are not in fact competitive, and for that reason the whole proceeding is probably illegal, since it is an established rule of public-works procedure that competitive bidding must be truly competitive in order to have validity.

In so far as the bidding is open to legal question it is opposed to the best interests of the taxpaying public, since the safeguards of law as applied to public contracts are wholly shaped by the dictates of the public interest. But the relation of the bidding to the public may be considered more directly by asking whether Lima is likely to obtain a satisfactory sewage-disposal plant and efficient river regulation under the plan it has adopted. The answer is that it may, but by virtue of its procedure it runs a wildly speculative chance. The city desired to procure the aid of fullest knowledge and experience toward the solution of two problems which will be of daily importance to its citizens for many years to come. The sole criterion of knowledge and experience which it set up, however, was the willingness of someone to ask a low price for the service. In other words, the city officials were willing to intrust these complex problems to anyone who might make a financially attractive offer.

To put it plainly on the basis of a commodity comparison—since the officials undertook to deal with expert service as a commodity—it is quite as though they offered to buy a pair of shoes, of unspecified size, comfort and durability, from anyone who would make the lowest price. On the part of a private individual, such action would be hopelessly absurd. On the part of public officials, affecting an entire city, it cannot be defended as in the public interest.

In the preceding we were concerned only with those factors that depend on the different degrees of competence of the several bidders. We assumed that all bidders were thoroughly conscientious and placed the interests of their client, the city, above their own. But when the affair is looked at from the viewpoint of the engineer invited to bid in such a competition, the matter is even more questionable. He is asked to undertake something of wholly indefinite character, something that can be done well or ill, slightingly or with careful study and research, and do it at the lowest possible price. His bid price will be lower as he can reduce his cost or trim his profit; and a low bid can be turned into a profitable one by reducing the quality of the thought and effort devoted to the work. Thus the engineer who enters into competitive bidding subjects himself voluntarily and knowingly to the risk of debasement of his own professional conscience, the net result of which is that the public will be defrauded of the service which it sought to obtain and for which it relied upon his professional standing and conscience.

Engineering competition has progressed steadily and insidiously. In some forms it is barely recognizable as competitive bidding, or as anything different from the normal engagement of an engineer; and perhaps for this reason professional societies have been timid about dealing with it. Seen in its fully developed form, however, as at Lima, it represents an active danger. It is at war with engineering competence and integrity and inevitably leads to deterioration of the service obtained by clients. All consideration of its effects, we believe, will show it to be against the public interest.

## The National Hydraulic Laboratory

THE first step in providing this country with a national laboratory adequate for the study of major hydraulic problems has been taken in the passage of the bill authorizing its construction as a part of the Bureau of Standards at Washington. The second step, the design of the laboratory itself, remains to be taken. Upon the flexibility and comprehensiveness of that design will depend much of the laboratory's usefulness in hydraulic studies.

Many of the problems which confront engineers in river and harbor work, in drainage and irrigation projects and in hydraulic power developments require studies on a scale of magnitude and scope not practicable in the hydraulic laboratories of the universities of this country. The national laboratory, therefore, should be built on adequately large scale. Dr. Oskar von Miller in building the Walchensee laboratory in Germany had so many doubts as to whether he was making his flumes large enough to handle sufficient water for satisfactory tests that he built an outdoor laboratory. Such a plan might well be followed at Washington. An outdoor laboratory with a minimum of buildings to house gages and mechanical equipment might in the end prevent the expenditure of large sums in providing housing for a laboratory later found to be inadequate in size or arrangement.

Experience in the construction of other laboratories which may act as a guide in designing this laboratory is not lacking. The hydraulic laboratories of Europe, described in a monumental report by the Verein Deutscher Ingenieure, recently published in English by John R. Freeman, and the results of many individual studies of hydraulic problems in smaller laboratories or with temporary set-ups, are available. Finally, there are men both in this country and in Europe who know the difficulties involved in working with limited facilities and who can from their own experience give much valuable advice.

Full utilization of accumulated experience with hydraulic laboratories for both channel and power work can make the Bureau of Standards laboratory superior to any yet constructed. It should be such, for our practical problems are larger and more manifold than those of other countries. The undertaking calls for the ablest efforts of the bureau's own engineers, aided by the counsel of the most experienced men in the profession.

# Backwater Gates Control Flow in Connors Creek Sewer, Detroit

## Gates Divert Dry-Weather Sewage Flow to Intercepting Sewer and Exclude River Water From Sewer

By Milton F. Wagnitz

*Engineer of Public Structures, City Engineer's Office, Detroit, Mich.*

DISCHARGE of the dry-weather flow of the Connors Creek sewer, at Detroit, Mich., into the Detroit River at the eastern end of the city has been prevented with the completion of an unusual backwater gate system. The dry-weather flow will be diverted to the Detroit River intercepting sewer along Jefferson Ave., which parallels the river, and upon its completion will discharge into it at a point below the city. This diversion will practically prevent sewage pollution from reaching the bathing beaches along the upper part of the river and will afford considerable protection against contamination of the city's water supply. At the same time the backwater gates will prevent the water in the river from flooding back into the Connors Creek sewer above Jefferson Ave.

The provision of backwater gates was recommended in a report on East Side sewerage and stormwater relief made to Perry A. Fellows, city engineer, in 1926, by Harrison P. Eddy, of Metcalf & Eddy, consulting engineers, Boston, Mass. A view of the gate chamber building is shown in Fig. 1, with a cross-section in Fig. 2, while Fig. 5 is a general plan of the station, showing its connections and backwater control. At the backwater gates the Connors Creek sewer serves an area of 17,070 acres and is designed for a stormflow of 6,000 sec.-ft. The ultimate maximum dry-weather flow is estimated at 211 sec.-ft. Just above the gate house the sewer is of double-box section, each box being 17 ft. 6 in. high and 22 ft. 11 in. wide. A general plan of the Connors Creek drainage area is shown in Fig. 3.

The diversion and backwater project consists essentially of four major parts: (1) the forebay or approach channel; (2) the gate chamber; (3) the tailrace, and (4) the regulator chambers. This entire structure below

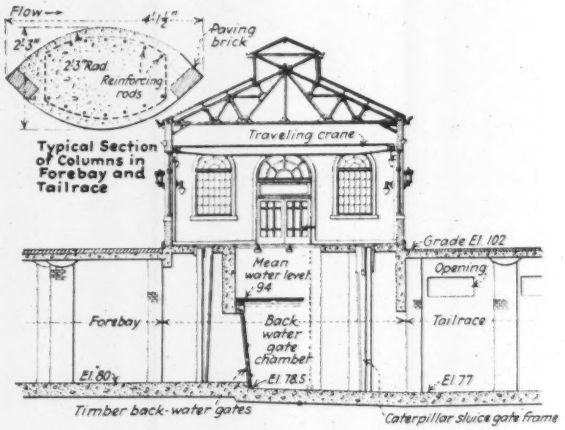



FIG. 2—GATE CHAMBER AND CONNECTIONS
Detail shows column section designed for minimum resistance to flow.

grade is of reinforced concrete. Its bottom slab is 3 ft. thick and is set on a double row of piles spaced 3 ft. center to center around the edges and through the center. In addition, it was necessary to build an outfall sewer for the Connors Creek stormwater pumping station, which is now under construction. This station outfall sewer is connected to the tailrace below the backwater gates. In constructing the Connors Creek sewer above the gate chamber, the riparian rights of the Hudson Motor Car Company were taken and an agreement was signed which enabled the city and the company jointly to construct a cooling-water conduit and screen house for the service of the company's plant.

*Forebay*—This basin above the gate house is formed

FIG. 1—BACKWATER GATE HOUSE ON DETROIT SEWER

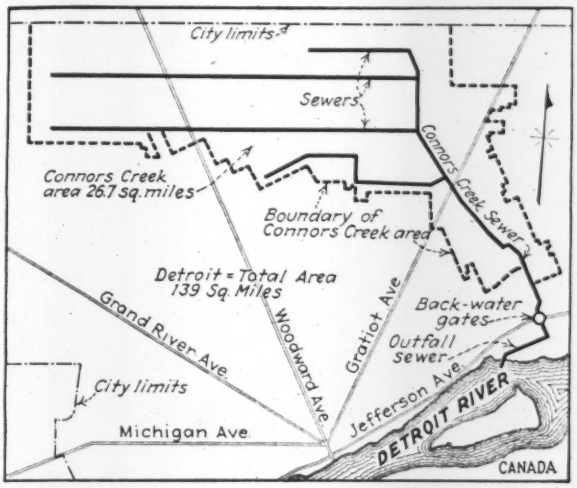



FIG. 3—DISTRICT SERVED BY CONNORS CREEK SEWER SYSTEM

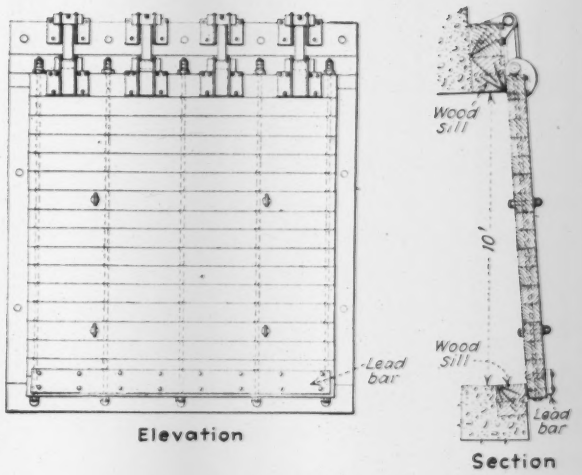



FIG. 4—HINGED BACKWATER GATES

by gradually increasing the width of the double-box Connors Creek sewer to the width required at the gate chamber. Its concrete roof slab is supported on concrete columns, which are designed to minimize resistance to the flow of stormwater, being of approximately oval section, as shown by the detail in Fig. 2. The bottom of the forebay is sloped to drain toward the regulator chambers. During low-water flow the resulting pond of sewage in front of the regulators is small, and deposits of mineral and organic matter over a large area in the forebay are prevented. A drainage system is provided under the floor to relieve the hydrostatic pressure.

*Gate House Structure*—The gate chamber consists of nine channels separated by heavy piers. Each channel is provided with an automatic timber backwater gate, supported at the top by four large double-pin hinges and covering an opening 10 ft. square. A difference of head of approximately 3 in. between the upstream and downstream sides is required just to unseat the gates. In time of maximum stormwater flow in the sewer the gates will swing open to about 15 deg. from the horizontal position.

These gates (Fig. 4) are constructed of selected creosoted yellow pine timbers 8x8 in., laid horizontally and fastened together by four 1¼-in. bronze binding rods supplied with self-adjusting nuts which permit of expansion and contraction. Each gate is balanced with approximately 1,100 lb. of lead, fastened near the bottom. The gates close against heavy timber frames fitted with rubber gaskets, but the openings are subject to a relatively small amount of leakage. The wall above the gate serves as a skimmer to prevent floating material from entering the tailrace and outfall sewer.

On each end of each backwater gate channel is a cast-iron frame in which a self-closing sluice gate can be inserted when it becomes necessary to repair or inspect the backwater gates. The sluice gate is made in two sections, forming a bulkhead 11x21 ft. A drain has been provided under the gate structure to which each channel is connected by a 12-in. gate, so that after the sluice gates are placed in the frames the isolated part of the channel can be dewatered to permit access to the timber gate.

Over the gate chambers is a rectangular steel frame building 128x42 ft., with columns carrying the roof trusses. Cut stone and red face brick are used for the

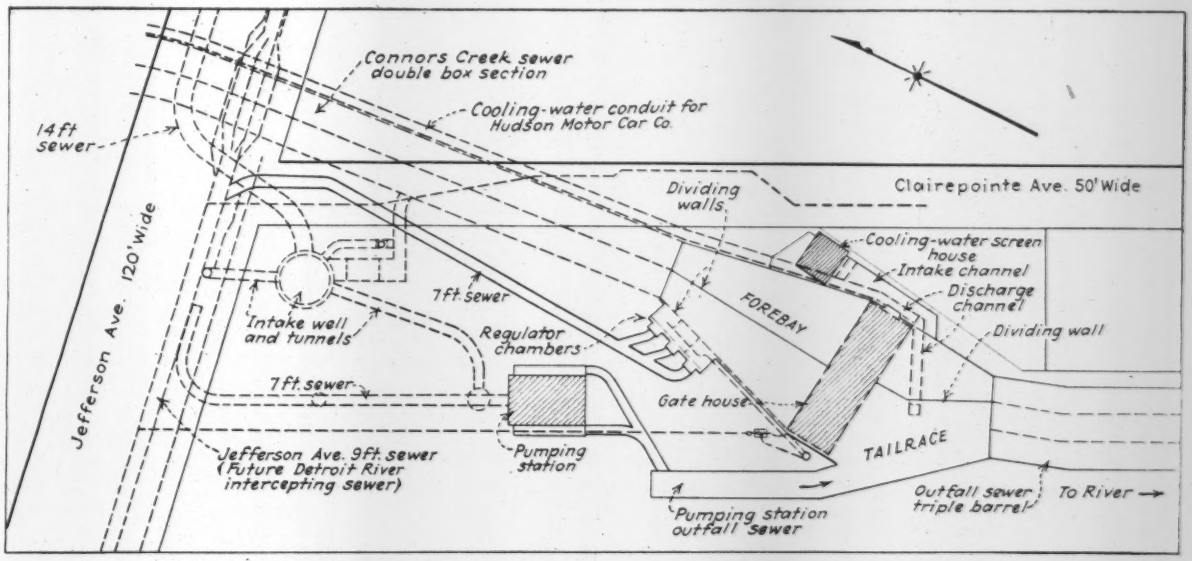



FIG. 5—BACKWATER CONTROL SYSTEM ON CONNORS CREEK SEWER, DETROIT

exterior, while the interior is of buff brick and the roof is covered with red Spanish shale tile. The floor around the openings for sluice gates and backwater gates is paved with red quarry tile. The architectural treatment is similar to that of the emergency pumping station on the same site, which was described in *Engineering News-Record*, May 23, 1929, p. 832. A 10-ton electric traveling crane has been installed for handling the self-closing sluice gates and the backwater gates.

*Tailrace*—This basin is similar in design to the forebay and has columns of the same oval section as those of the forebay. It decreases gradually in width from the gate structure to the junction with the Connors Creek outfall sewer, now under construction. Weirs have been provided in the dividing wall above the normal water elevation to equalize the level in the three barrels of the outfall sewer during stormflow. This outfall sewer, with a capacity of 8,400 sec.-ft., consists of three rectangular concrete boxes, each 18 ft. 6 in. wide and 21 ft. 9 in. high.

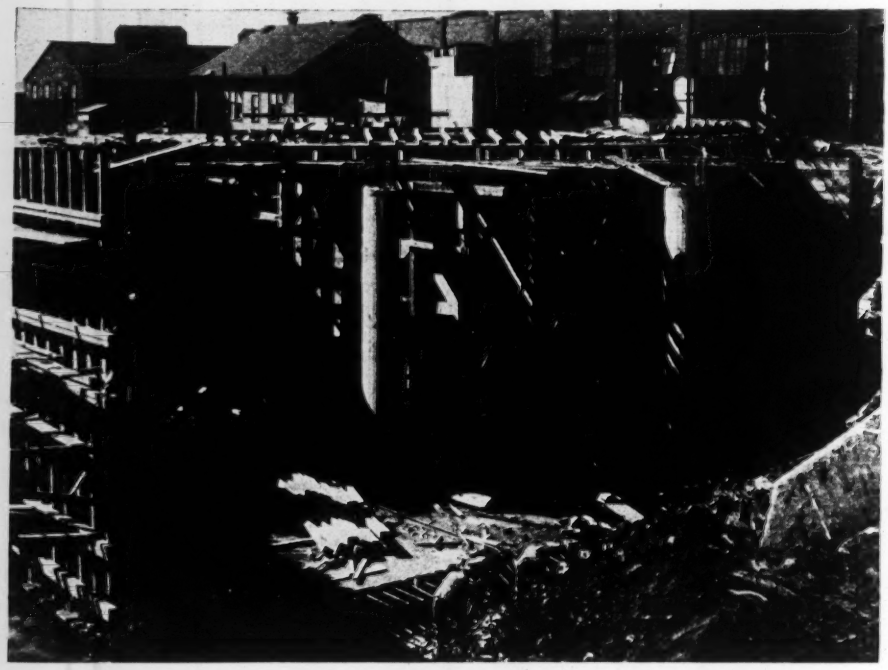


FIG. 7—BUILDING FOREBAY FOR SEWAGE CONTROL

*Regulators for Sewage Flow*—Three 54-in. regulators, housed in separate chambers adjacent to the forebay, will divert the flow of dry-weather sewage from the Connors Creek sewer to the Detroit River intercepting sewer through a 7-ft. cylindrical conduit. These regulators, (Fig. 6) are of the float-operated flap valve type, and are connected to the floats by means of a system of levers. Each flap valve has two floats, which are controlled by the level of the sewage in the intercepting sewer and are set to close at a predetermined level. The regulator chambers are provided with motor-operated sluice gates on each side of the flap valves in order to permit of shutting off any chamber from sewage flow and making the regulators accessible for adjustment and repair.

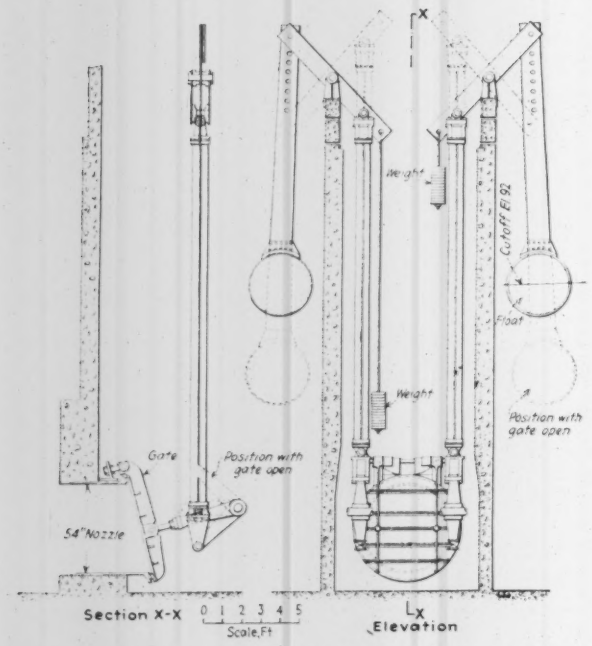



FIG. 6—REGULATORS FOR DRY-WEATHER SEWAGE FLOW

*Cooling Water System*—Provision for the cooling water system for the Hudson Motor Car Company's plant consists of a screen house with intake and discharge conduits which are connected to the tailrace on opposite sides of the center wall, as shown in Fig. 5. On completion of the Connors Creek outfall sewer this arrangement will provide 14,000 ft. of circulation for the condensing water used in the motor car plant. The screen house has four channels, each containing a traveling screen for removing trash and also fitted with sluice gates which make it possible to shut off any channel. The superstructure was built and the equipment furnished by the company.

*Miscellaneous*—Gage wells at the inlet end of the forebay, at each end of the gate channel and at the outlet of the tailrace enable observations to be made to determine the loss of head through the entire structure during stormflows.

*Construction Methods*—As it was necessary for the contractor to maintain the flow in the Connors Creek sewer, half of the structure had to be constructed inside a steel sheetpile cofferdam, with a bulkhead in one barrel of the sewer. On completion, the flow was diverted through this half while the second half was built. Fig. 7 shows the forebay and its columns under construction.

*Designers and Builders*—The general contract was let to Lennane & McIlvenna, Detroit, Mich., for $449,921. The timber backwater gates and the regulators were built by the August N. Johnson Machine Company, Manistee, Mich., and the self-closing sluice gates by Phillips & Davies, Kenton, Ohio. This backwater control system was designed in the Bureau of Public Structures, of which the writer has charge, under the direction of Perry A. Fellows, city engineer, and John W. Reid, commissioner of public works, Detroit, Mich.

# Strength and Arrangement of Pipe for Airport Drainage Systems

## A Discussion of the Fundamentals of Such Drainage, Together With Tabular Data for Calculating Plane Impact Effects

By Harry E. Cotton
*Municipal Engineer,*
*Armco Culvert Manufacturers Association, Middletown, Ohio*

AIRPORT drainage differs from other forms of drainage. Although it is comparable to usual storm-sewer design, in that surface water must be carried away by underground conduits, the water at airports must be collected without resorting to ditches or gutters. On sloping fields surface water must be intercepted at frequent intervals to eliminate erosion of the soil, and on level fields the water must be removed quickly before it can soften the surface soil to the point that stability will be destroyed. Many fields also will require subsurface drainage to control the water table.

The first essential and the basis of the design is a topographical map showing:

1. One-foot contours of the finished field, a convenient scale being 1 in. = 200 ft.
2. Hangars and other buildings from which it will be necessary to remove runoff through the drainage system.
3. Impervious surfaces such as runways, taxiways or aprons.
4. Additional areas adjoining the airport which drain onto the field.
5. Elevations and location of all available outlets.
6. Location of soil test holes.

So far as precipitation is concerned, a design based on the removal within three hours of the runoff from an average maximum one-hour rainfall which is exceeded only once a year will be found to be rational and economical.

For subsurface runoff, it is recommended that a minimum of ½-in. runoff per 24 hours be used, to be increased to ¾ in. or even to 1 in. in regions of exceptionally heavy rainfall where unusually pervious soils are encountered. Determination of surface runoff, depending upon soils, slopes, etc., is largely a matter of judgment with the engineer.

*Depth and Spacing of Drains*—The nature of the soil is a vital factor in determining depth and spacing of subdrains. Soils have been classified by the U. S. Bureau of Soils according to their texture as shown in Table I, and the depth and spacing shown here have been arrived at by the author, using mechanical analysis of the soils plus field observations. A procedure for such an analysis is suggested as follows: Test holes should be bored or excavated at representative points on the field to depths of 4 to 6 ft., or until an impervious stratum is encountered. Soil samples should be procured of each soil stratum encountered, and its top and bottom depths carefully noted. Also the depth of the water table, if any, should be carefully noted and the relative rate of infiltration of groundwater observed. From a mechanical analysis of the soil samples the soil can be classified as shown in Table I and a soil profile plotted of each test hole. In this way the character of the soil to be encountered in each part of the field, together with the elevation of the water table, can be seen at a glance. Incidentally, such a record may be of considerable value in checking the drainage system's efficiency in the future.

Abstract of a paper delivered before a meeting of the Iowa Engineering Society at Council Bluffs, Iowa.

PLACING GRAVEL IN SURFACE INTERCEPTING DRAIN TRENCHES, ROCHESTER, N. Y.

Cost often limits the amount of drainage which can be installed, but the system may be planned so that additions can be made as funds become available.

*Layout of System*—In general, for an all-over sod field, the drainage layout will be much the same as for agricultural drainage, the mains and submains following drainage traces, with laterals branching out and arranged so that the area of double drainage is reduced to a minimum. Where surface water is to be removed, it is essential that the drains be placed at right angles to the surface slopes.

For a field with runways, drains to intercept surface water should be placed on each side of and adjacent to the runways. In other portions of the field, a gridiron or parallel system of laterals may be used, emptying into the submains along the runways or into a separate lower outlet, if necessary. Where funds are limited, only the surface water intercepting drains along the projected runways and the outlet mains need be placed. The subdrains under the runways and the field subdrains can be added later without scrapping any previous construction.

Drains intercepting surface water should have their trenches backfilled up to the surface with gravel or crushed rock. The top layer of 6 in. should consist of

TABLE I—RECOMMENDED DEPTHS AND SPACING OF SUBDRAINS FOR VARIOUS SOIL CLASSES

| Soil Classes | Percentage of Soil Separates: Per Cent Sand | Per Cent Silt | Per Cent Clay | Depth to Flow Line of Drain, Ft. | Distance Between Subdrains, Ft. |
|---|---|---|---|---|---|
| Sand | 80–100 | 0–20 | 0–20 | 3–4 | 150–300 |
| | | | | 2–3 | 100–150 |
| Sandy loam | 50– 80 | 0–50 | 0–20 | 3–4 | 100–150 |
| | | | | 2–3 | 85–100 |
| Loam | 30– 50 | 30–50 | 0–20 | 3–4 | 85–100 |
| | | | | 2–3 | 75– 95 |
| Silt loam | 0– 50 | 50–100 | 0–20 | 3–4 | 75– 85 |
| | | | | 2–3 | 65– 75 |
| Sandy clay loam | 50– 80 | 0– 30 | 20– 30 | 3–4 | 65– 75 |
| | | | | 2–3 | 55– 65 |
| Clay loam | 20– 50 | 20– 50 | 20– 30 | 3–4 | 55– 65 |
| | | | | 2–3 | 45– 55 |
| Silty clay loam | 0– 30 | 50– 80 | 20– 30 | 3–4 | 45– 55 |
| | | | | 2–3 | 40– 45 |
| Sandy clay | 50– 70 | 0– 20 | 30– 50 | 3–4 | 40– 45 |
| | | | | 2–3 | 35– 40 |
| Silty clay | 0– 20 | 50– 70 | 30– 50 | 3–4 | 35– 40 |
| | | | | 2–3 | 30– 35 |
| Clay | 0– 50 | 0– 50 | 30–100 | 3–4 | 30– 35 |
| | | | | 2–3 | 25– 30 |

TABLE II—TRANSMITTED LIVE LOAD ON PIPE IN POUNDS PER LINEAR FOOT BASED ON FORMULA $W_t = \frac{C_t T}{L}$

| Diam. of Pipe, In. | Length of Section, Ft. | 1.0 Ft. Cover: $C_t$ for Load Directly Over Center of Section | 1.0 Ft. Cover: Live Load Per 1,000 Lb. of Surface Load | 1.5 Ft. Cover: $C_t$ for Load Directly Over Center of Section | 1.5 Ft. Cover: Live Load Per 1,000 Lb. of Surface Load | 2.0 Ft. Cover: $C_t$ for Load Directly Over Center of Section | 2.0 Ft. Cover: Live Load Per 1,000 Lb. of Surface Load | 3.0 Ft. Cover: $C_t$ for Load Directly Over Center of Section | 3.0 Ft. Cover: Live Load Per 1,000 Lb. of Surface Load | 4.0 Ft. Cover: $C_t$ for Load Directly Over Center of Section | 4.0 Ft. Cover: Live Load Per 1,000 Lb. of Surface Load | 5.0 Ft. Cover: $C_t$ for Load Directly Over Center of Section | 5.0 Ft. Cover: Live Load Per 1,000 Lb. of Surface Load |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | 1 | 0.20516 | 205.2 | 0.09908 | 99.1 | 0.05741 | 57.4 | 0.02607 | 26.1 | 0.01477 | 14.8 | 0.00949 | 9.5 |
| 6 | 2 | .28339 | 141.7 | .15981 | 79.9 | .10037 | 50.2 | .04886 | 24.4 | .02846 | 14.2 | .01852 | 9.3 |
| 12 | 2 | .49752 | 248.8 | .30036 | 150.2 | .19356 | 96.8 | .09610 | 48.0 | .05639 | 28.2 | .03682 | 18.4 |
| 12 | 3 | .54029 | 180.1 | .35488 | 118.3 | .24446 | 81.5 | .13113 | 43.7 | .07982 | 26.6 | .05314 | 17.7 |
| 12 | 4 | .55411 | 138.5 | .37894 | 94.7 | .27265 | 68.2 | .15631 | 39.1 | .09892 | 24.7 | .06737 | 16.8 |
| 18 | 2 | .63328 | 316.6 | .41129 | 205.6 | .27745 | 138.7 | .14031 | 70.2 | .08326 | 41.6 | .05466 | 27.3 |
| 18 | 3 | .69198 | 230.7 | .48812 | 162.7 | .34751 | 115.8 | .19162 | 63.9 | .11790 | 39.3 | .07890 | 26.3 |
| 18 | 4 | .71151 | 177.9 | .52259 | 130.6 | .38834 | 97.1 | .22860 | 57.1 | .14617 | 36.5 | .10004 | 25.0 |
| 24 | 2 | .71189 | 355.9 | .49235 | 246.2 | .34083 | 170.4 | .18047 | 90.2 | .10869 | 54.3 | .07189 | 35.9 |
| 24 | 3 | .78232 | 260.8 | .58712 | 195.7 | .43287 | 144.2 | .24673 | 82.2 | .15397 | 51.3 | .10379 | 34.6 |
| 24 | 4 | .80652 | 201.6 | .63044 | 157.6 | .48485 | 121.2 | .29487 | 73.7 | .19098 | 47.7 | .13163 | 32.9 |
| 30 | 3 | .83548 | 278.5 | .65731 | 219.1 | .50071 | 166.9 | .29567 | 98.6 | .18753 | 62.5 | .12748 | 42.5 |
| 30 | 4 | .86329 | 215.8 | .70788 | 177.0 | .56223 | 140.6 | .35355 | 88.4 | .23275 | 58.2 | .16173 | 40.4 |
| 36 | 3 | .86657 | 288.8 | .70595 | 235.3 | .55310 | 184.4 | .33817 | 112.7 | .21835 | 72.8 | .14992 | 50.0 |
| 36 | 4 | .89713 | 224.3 | .76227 | 190.6 | .62256 | 156.4 | .40512 | 101.3 | .27118 | 67.8 | .19025 | 47.6 |
| 42 | 4 | .91819 | 229.5 | .80012 | 200.0 | .66873 | 167.2 | .44895 | 112.2 | .30601 | 76.5 | .21686 | 54.2 |
| 42 | 6 | .93771 | 156.3 | .84480 | 140.8 | .73602 | 122.7 | .53618 | 89.4 | .38906 | 64.8 | .28795 | 48.0 |
| 48 | 4 | .93121 | 232.8 | .82653 | 206.6 | .70373 | 175.9 | .48636 | 121.6 | .33728 | 84.3 | .24162 | 60.4 |
| 48 | 6 | .95204 | 158.7 | .87453 | 145.8 | .77659 | 129.4 | .58213 | 97.0 | .42943 | 71.6 | .32108 | 53.5 |

angular crushed rock 2 to 3 in. in size, while the remainder of the backfilling should be graded from the size of coarse sand up to ½ in. The large angular rock on top will not easily be displaced by airplane traffic, and if white or light-colored rock is used, it will serve as a distinct marker for the runways.

*Requirements of Airport Drains*—Pipe should be installed so that it will retain its grade and alignment undisturbed. This requirement is assisted by securely connecting pipe sections together and providing perforations in the pipe for admitting water. The strength of pipe is also a vital factor, and must be great enough to withstand dead load of backfill and the live load of airplane impact. The Iowa Engineering Experiment Station, Ames, Iowa, has made investigations bearing on these points and has published its results in two bulletins: Bulletin 31, entitled "The Theory of Loads on Pipe in Ditches, and Tests of Cement and Clay Drain Tile and Sewer Pipe," and Bulletin 79, entitled "Experimental Determination of Static and Impact Loads Transmitted to Culverts." The latter investigation was made for motor trucks, but its results are applicable to airplanes as well.

According to Bulletin 79, the live load on pipes in ditches, or that part of the surface load transmitted through the fill material, may be computed by using the formula $W_t = \frac{C_t T}{L}$, in which $W_t$ is the total corresponding load, per unit of length, transmitted to the top area of the test section, $C_t$ is a calculated coefficient of transmitted load, $T$ is the total concentrated load applied at one point on the surface of the embankment, and $L$ is the length of test section in feet.

The values of $C_t$ shown in Table II have been calculated from data noted in Bulletin 79. The calculated live loads per 1,000 lb. of surface load which are transmitted through fills of 1 to 5 ft. on pipes of 6- to 48-in. diameter, as shown in this table, can be used as a basis for determining loads on pipe. For example, aeronautical authorities agree that the amount of impact force imposed on the surface of the field when a landing plane first strikes the ground lies between 2 and 6½ times the weight of the plane and that the proportion is less for the larger planes than for the smaller ones. The heaviest planes now manufactured weigh about 30,000 lb., or 15,000 lb. on each wheel. Assuming a factor of impact of 2, the live load per wheel would be 30,000 lb. Utilizing Table II, which gives the load transmitted to a pipe per 1,000 lb. of surface load, the load transmitted by a 30,000-lb. load can be computed by multiplying the tabulated value by 30. To this the dead load or fill must be added to secure the total load on the pipe.

It has been amply demonstrated both in the field and in the laboratory that corrugated iron pipe will support, with perfect safety, loads much heavier than those calculated by the above method. Railroads are using it for shallow drains under tracks where severe impact loads are encountered, as well as for large diameter culverts under fills approximately 100 ft. high.

## Steam Averts Freezing of Water Mains at Leadville, Colo.

SUBZERO weather that freezes ground to a depth of 9 ft. will not menace the municipal water system at Leadville, Col., it is believed, since the installation of two additional boilers to prevent ice formation in the mains.

The water pipes at Leadville are buried 6 ft. below the surface, which is deep enough to protect them against all ordinary and nearly all extraordinary conditions. During the winter of 1928-29, when little snow blanketed the ground and one week of extremely cold weather followed another, heroic measures were required to prevent water from freezing. The steam boiler at the municipal pumping plant was connected to one of the 8-in. city mains and steam was forced into the line until the water temperature was raised above the danger point. When necessity arose the Public Service Company of Colorado loaned a boiler from its steam-electric generating plant for a similar service. By these measures a general stoppage of the water supply was prevented.

In 1929 the city added two boilers to the installation at the pumping plant. These and the one previously installed are all of 80-hp. capacity designed for 100-lb. pressure. They can deliver live steam at 250 to 300 deg. F. directly into the mains whenever necessary. The steam is injected until the water temperature reaches about 40 deg. F., the process being repeated as often as necessary.

Because the boilers are located on a high hill where the water pressures are considerably decreased, steam can be injected into the mains under a pressure of only 30 to 40 lb. per square inch as compared with approximately 80 lb. that would be required if the plant were located in the central part of the city.

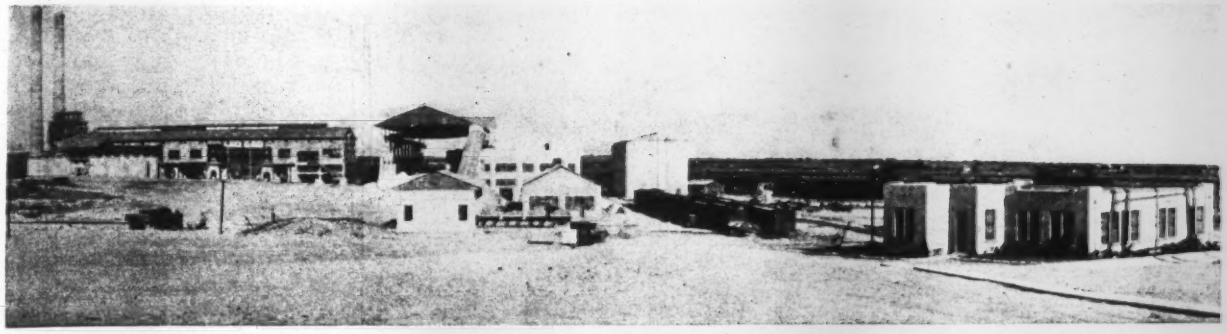


FIG. 1—WET-PROCESS PLANT OF REPUBLIC PORTLAND CEMENT COMPANY, SAN ANTONIO, TEX.
Kilns and mills at right angles to the storage bins permit easy unit extensions.

# Layout and Construction of a New Wet-Process Cement Plant in Texas

## Large Variety of Concrete Structures, Including an Unusual Craneway Frame—Manufacturing Features Include Quarry of Ready-Mixed Clay and Limestone, Large Grinding Capacity and Close Chemical Control

By Terrell Bartlett
*Consulting Engineer, San Antonio, Tex.*

STRUCTURAL and manufacturing features of a recently completed wet-process cement mill near San Antonio, Tex., for the Republic Portland Cement Co. involve the following factors of interest: site selection; easily available quarry material in one place; layout of plant to reduce costs to a minimum; use of an unusual amount of concrete in the structures; a concrete craneway frame; foundations on both rock and clay; large grinding capacity; close control, and silo construction for the stock house.

The demands of the modern engineer, as respects the quality and the characteristics of the cement which he uses, received particular consideration in planning this plant. Also in selecting the raw material deposits, it was not sufficient that the materials themselves be of proper quality and quantity, but numerous other conditions had to be met. These embraced the choice of a location which would provide a switching rate to the San Antonio market, yet would be sufficiently removed to be safe for many years from residential additions near the plant; ease of handling the material; a quarry site which would permit development of a good face without necessity of pumping for drainage; accessibility to two trunk-line railways and to highways; and the possibility of securing an abundant water supply.

*Location*—The plant is located 8 miles northeast of San Antonio, near the San Antonio-Austin Post Road, adjacent to the main line of the Missouri, Kansas & Texas Railroad; it has trackage connections to that line, and also, by a 3-mile spur, to the Missouri Pacific lines. The raw materials are close at hand and come from the upper and middle zones of the Austin Chalk of the Upper Cretaceous. At this site that formation is an argillaceous chalk, and a large volume opposite the center of the face carries, intimately mixed, within 2 per cent over or under, the correct proportions of clay and limestone for making cement. The lower beds, which rise with the moderate dip into one end of the quarry, are gradually higher in lime content, with nearly pure limestone available on the property. The higher strata in the other end of the face are more argillaceous. Instead of the usual mixing of two distinct materials from separate formations, the problem of securing the proper raw mix is reduced at this plant to the comparatively simple operation of correcting the raw material by slight admixtures of materials higher or lower in lime content.

*Quarry*—The quarry was opened parallel to the dip and to a natural ravine which was lowered to give an initial face of 25 ft. with natural drainage of the floor. Drilling is done by a self-propelling electric well-drill supplemented by a wagon air-drill. Major excavation is handled by an electrically operated full-crawler shovel with 2-cu.yd. bucket, and material for correcting the mix by a 1-cu.yd. crawler gasoline shovel. The material is hauled about 1,000 ft. up a light grade by a gasoline locomotive to the crushing plant in trains of six 8-yd. standard-gage quarry cars with all-steel dump bodies.

The quarry cars are spotted successively at the crusher hopper by a chain drag, which also clears the empty trains into a dip siding without assistance from the locomotive. The cars are dumped by a self-attaching, self-clearing, counterbalanced bracket arm and hook, actuated by an overhead motor-driven hoist. The material slides from the hopper onto an apron pan feeder driven by a variable-speed motor permitting regulation of delivery into the crusher. The single crusher is a maximum-size hammer mill, selected because of its moving breaker plate, which obviates clogging when the material is wet and sticky. All parts of the quarry, transportation, feeding and crusher equipment are capable of handling rock as large as 2-yd. size and reducing it in one operation to $\frac{3}{4}$ in. and smaller. The spotting, dumping and clearing of cars, the rate of feed and the starting and stopping of the crusher are handled by one operator from a control table adjacent to the hopper at track level.

*Crusher*—In order to permit the locomotive to bring cars to the crushing plant without a hoist incline, the crusher and discharge tunnel beneath are set in a deep pit excavated in solid rock. This puts the major lift from quarry to raw-material bins on the inclined belt conveyor. The crusher discharge and spillage from the feeder are delivered by a series of hoppers to the 36-in. belt, which rises on a 16 deg. incline, first through the tunnel, then on a reinforced-concrete trestle to the end of the storage structure, where it levels out alongside the storage structure and the raw mill feed bins. The crushed stone may be dumped by a movable tripper into either of two spouts leading to the storage, or by dust-screened hoppers, directly into the feed bins.

*Storage*—The storage structure consists of a reinforced-concrete craneway frame, 300 ft. long and 70 ft. center to center of the crane beams, which are carried 50 ft. above ground level. The concrete crane beams span 25 ft. between the buttressed concrete columns and are continuous except for one expansion joint at a split column in the center of the 300 ft. on one side and at sliding supports at intersections with the bin structure on the other side. The storage is divided into five bays for raw-material storage and seven bays for clinker and gypsum. The row of mill feed bins for stone, clinker and gypsum is within and along one side of this structure, centered on the division wall. Except at the bins the material is retained along the sides of the storage by paved earthfills 10 ft. high arranged so as to be equivalent to the more usual 20-ft. vertical wall.

The crane is electrically operated and carries a 3-cu.yd. bucket. All of the raw storage and half of the clinker storage is under a steel-trussed roof with wide projecting eaves carried clear of the crane by stub steel columns resting on the concrete structure. The storage can be closed in by stucco walls carried on light steel framing attached to the concrete columns.

In designing the concrete crane beams it was necessary to take account of the impact of the loaded crane, weighing some 50 tons, and of the thrust from the transverse movement of the crane trolley. In addition, the concrete columns have to carry the transverse wind load from roof and siding. The slight support across the structure, afforded in part of the length by the roof trusses and steel columns, was ignored, necessitating that each side be self-supporting. This resulted in buttress-shaped columns 18x60 in. in base section, carried on reinforced spread footings 17 ft. long, resting on rock. The columns are connected at the top by the crane beam and at mid-height by a row of double-corbelled concrete struts. It was at first thought that the frame would yield sufficiently under temperature changes to make an expansion joint unnecessary for the 300-ft. length, but an analysis showed considerable temperature stresses in the end columns. As a consequence the joints referred to were introduced.

*Materials and Assumptions*—It should be stated that by reason of the nature of the industry the use of concrete was considered to be good policy wherever its cost would be approximately equal to or less than steel. Steel

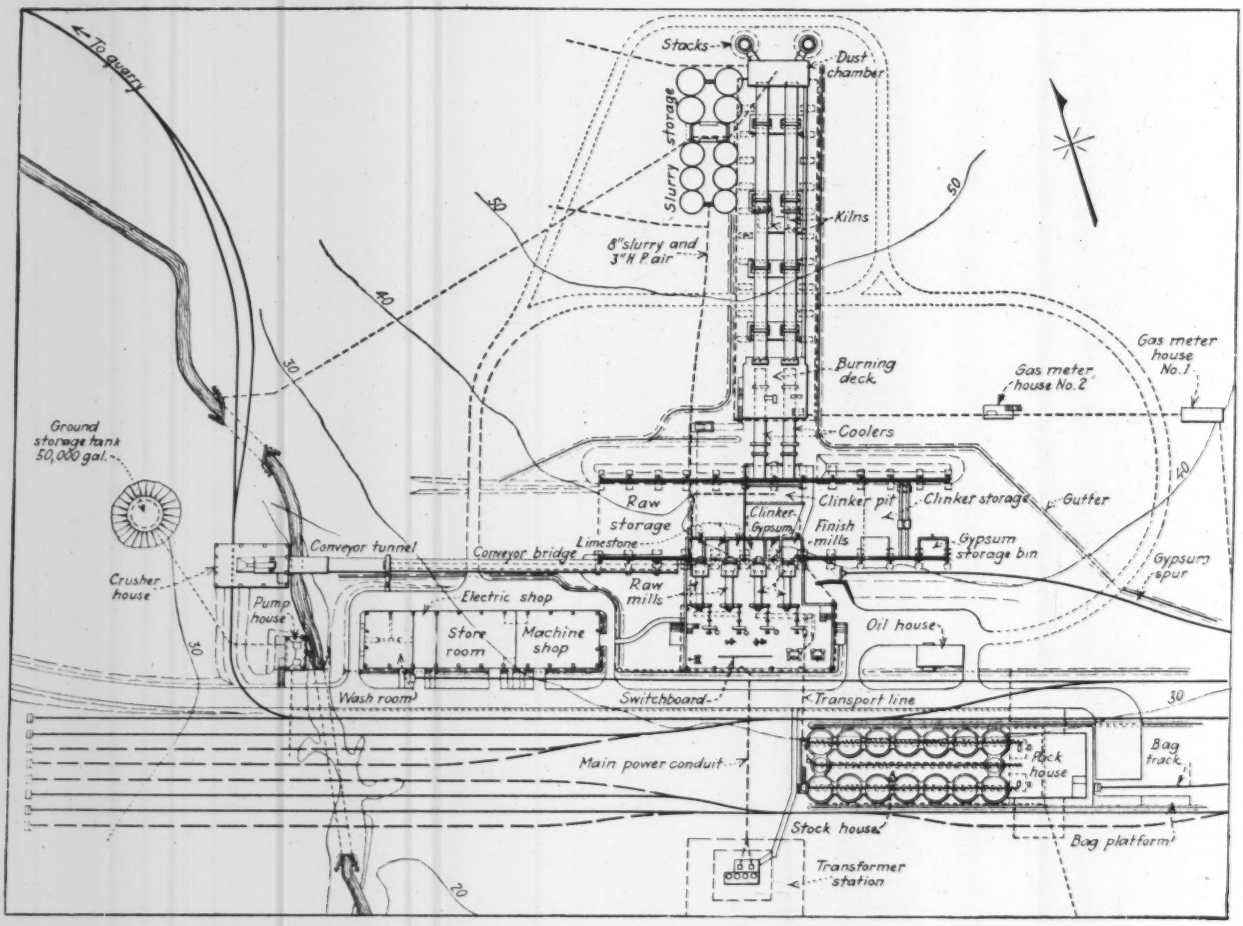



FIG. 2—REPUBLIC CEMENT PLANT WAS LAID OUT TO FACILITATE FUTURE ADDITIONS

is relatively more costly in Texas than in some other parts of the country because of high freight charges, while concrete is cheaper on account of labor conditions. The use of structural steel was accordingly restricted to long spans or to facilitate future enlargements of the buildings. The result of this policy and of care in the structural designs of both types of construction was that the structural metal used in the plant was some 2,000 tons less and concrete from 3,000 to 5,000 cu.yd. greater than usually used in a cement mill of equal capacity. Concrete was designed under joint committee recommendations for 2,500-lb. strength with steel stresses ordinarily restricted to 16,000 lb. but raised to 20,000 lb. where future loadings were uncertain as in heavily stressed massive foundations. Corrugated cement asbestos was used for sloping roofs, cement tile or stucco for walls, and gunite for the largest flat roof.

The mill feed bins are of concrete with hopper bottoms and one fully sloped side. Their aggregate capacity is 1,370 tons. There are two groups of three bins each, two for high and one for low limestone, and two for clinker and one for gypsum, arranged to feed respectively to the two raw grinding mills and to the two finished cement-grinding mills. The center bins for raw material and gypsum are forked to double-outlet hoppers.

The mill building is 54 ft. high and 94x100 ft. in plan, in addition to a basement and feeder deck, extending back under the bins; also it has a 25-ft. wing on one end. One end of the roof is carried by the bin and crane columns, the other by concrete columns. There is a central row of columns affording support for a mezzanine floor and an intermediate bearing for the roof trusses which are designed as continuous frames. End-framing was structural steel to permit the ready extension of the building to house additional mills.

*Foundations*—An unusual foundation condition was encountered under the mills at one end of which was a soft rock, while at the other end was a joint clay. Each of the mills with its grinding charge weighs 200 tons, most of which rotates at 20 r.p.m. Each drive motor with its shafting and gears weighs some 25 tons in addition. Rigidity of the motor, shafting and gears at the drive end is important. The foundation condition was met by placing the feed end of each mill on a relatively small individual foundation on the rock, and the drive ends of all four mills, with their shafting and motors, and the intermediate building columns on a single heavy, reinforced mat of large area. The supporting power of the joint clay is good, but the material is tricky because of its considerable volume change with varying moisture content.

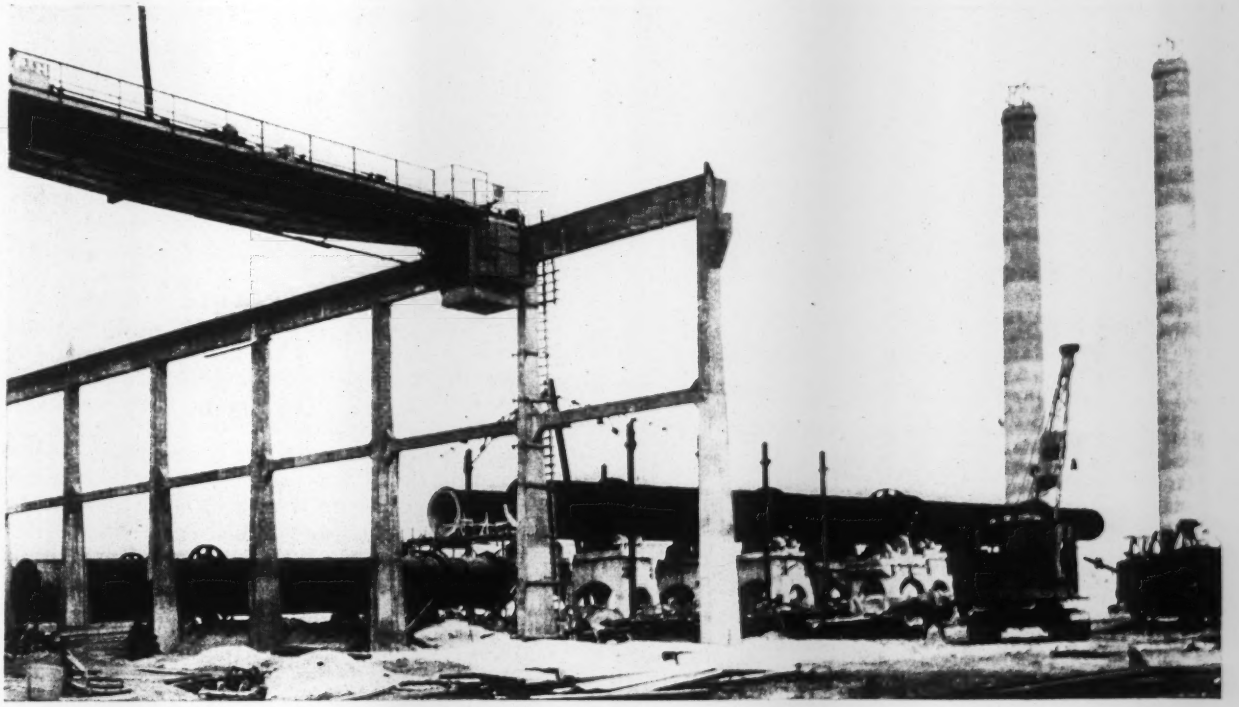


FIG. 3—REINFORCED-CONCRETE CRANEWAY FRAME IN TEXAS CEMENT PLANT
Kilns and coolers in the background at right angles to raw and clinker storage. The columns are buttress-shaped

*Feed and Mix*—Returning to follow the course of the material through the plant, the two grades of raw material are drawn from spouts in the bin bottoms by four 6-ft. diameter rotating table feeders, two per mill. The total and relative rates of feed are subject to three adjustments—the speed of the direct-current motor which rotates each table, the vertical opening between spout and table and the position of the blade which scrapes the material from the table. The crushed stone falls from the table and enters the mill by a spout through the center of the trunnion bearing. The water for the wet grinding also feeds down this same spout. It is at this point that the chemist makes his first approximation of the desired mix by regulating the feed of the two grades of limestone based on analyses of the quarry drilling samples which are systematically made and mapped foot by foot from each drill hole.

In the dry-process mills, the regulation of the feed of raw materials into the grinding mill is the only means of adjusting the composition of the product.

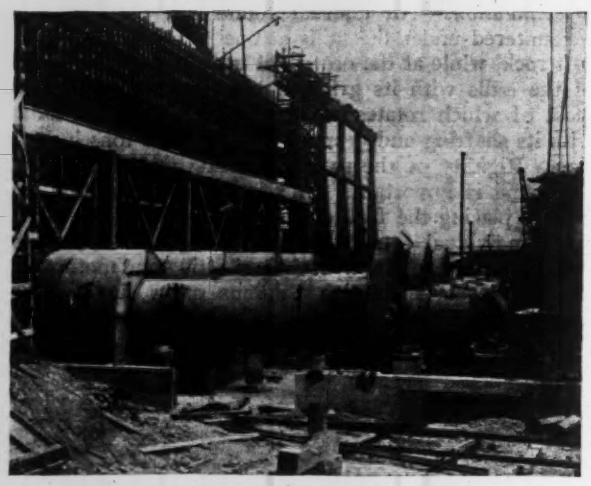


FIG. 4—ERECTING THE GRINDING MILLS
The rigidity of the motor, shafting and gears at the feed end (left) is secured by comparatively small single foundations on rock. The supporting power of the joint clay at the drive end (right) is stabilized by covering a large area for all four mills with a reinforced-concrete mat.

The great superiority of the wet process in maintaining uniformity and high quality of product, particularly with such facilities as provided in this plant, will be apparent from the description of the subsequent analyses, readjustment, remixing and rechecking of the raw material before it goes to the kilns for burning. Some of the newer dry-process plants realize an improvement in the final raw mix by utilizing blending bins and air pumps for handling the raw material in dust form, but the greater ease of mixing the wet slurry, the greater safety from segregations and the possibility of continued stirring by agitation make it quite apparent that uniform and dependable cement can be more readily made by the wet process. It is on this account that the wet process was adopted for this plant, notwithstanding that the cost of manufacture by the dry process is cheaper.

*Slurry*—The raw material is ground to a fineness of 90 to 95 per cent through a 200-mesh sieve, and falls from the mills into a sump as the creamy mud known as "slurry." At this point the chemist checks his mix by hourly samples. Extreme fineness of grinding of the raw materials is equally or more important than with the finished cement, particularly where high early strengths are desired in the cement produced. Large raw grinding capacity was accordingly provided in this plant.

In the receiving sump referred to the slurry is agitated by a double-ribbon conveyor, and thence it is pumped continuously by one of duplicate pumps—a special type centrifugal—through a 10-in. pipe which crosses the mill building basement, passes under the storage through a tunnel and is delivered to the slurry-receiving tanks located on the opposite side of the plant adjacent to the feed end of the kilns. There are six concrete-receiving tanks, 20 ft. in diameter and 30 ft. high, and four correcting or kiln feed tanks 24 ft. in diameter and of the same height. The tanks are symmetrically grouped about a transverse pipe gallery, and between the two kinds of tanks is a pump sump, in which are two slurry-receiving sumps, duplicate transfer pumps and duplicate kiln feed pumps. The tanks carry an operating deck, level with their tops, from which the inlet slurry and air valves to the various tanks are served and on which are the electric control panels and the motors which drive the combined mechanical and air agitators with which each of the ten tanks is equipped.

*Final Control*—The final accurate control of the mix is accomplished in the following manner: In one of the six receiving tanks a slurry is carried somewhat high and in another somewhat low in lime content. After each of the other receiving tanks is filled, it is thoroughly agitated and sampled at a number of depth intervals. The chemist computes the amount of correcting slurry to be drawn with it and the slurry is then drawn simultaneously at proper rates from the two tanks and transferred to one of the kiln feed tanks. It is thoroughly mixed by the pump sump agitator and pump, and again agitated in the large tank and kept agitated. After transfer, a check analysis is made. If its proportions are not correct, pipe connections are provided so that the material need not be wasted but can be further corrected or returned to the receiving tanks. These facilities make it possible in ordinary routine practice to regulate the desired proportions within 0.15 per cent.

*Kilns*—The two kilns are steel drums, 11 ft. in diameter and 250 ft. long, lined throughout with firebrick, with an especially high-quality brick in the burning zone. Each kiln is provided with four heavy steel tires resting on pairs of rollers and is turned at from $\frac{1}{2}$ to 1 r.p.m. by a pinion and girt gear. The pinion shaft is driven through quadruple-reduction gearing with 1,200 to 1 ratio, by a variable-speed direct-current motor. The kilns are mounted on an incline of $\frac{3}{8}$ in. per foot. The

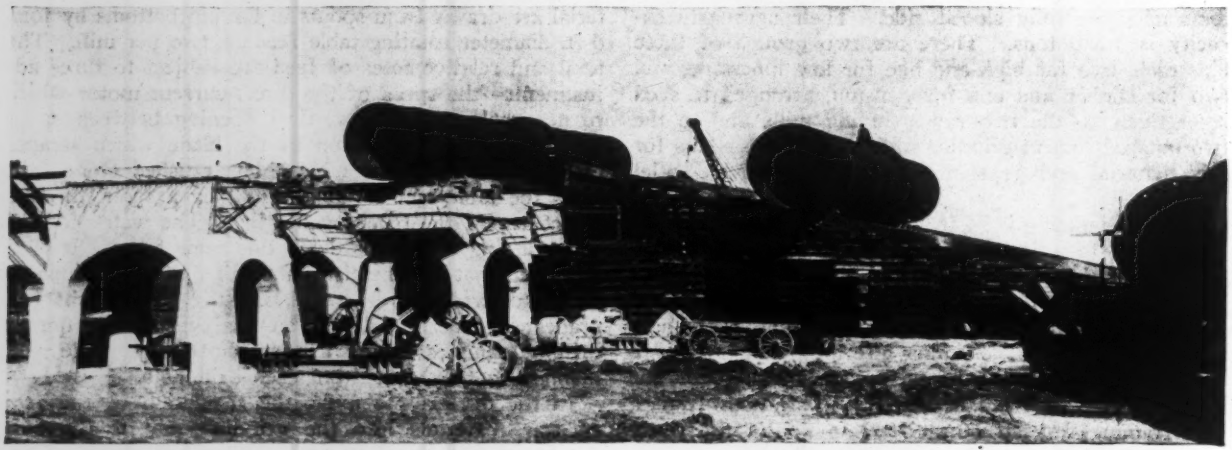


FIG. 5—ERECTING THE KILNS BY ROLLING THEM INTO PLACE

upper or feed end projects into a firebrick-lined and insulated hopper-bottomed dust chamber, which connects by steel breeching to the reinforced-concrete stacks.

The dust chamber carries the feed deck. For each kiln there is a bucket-wheel feeder driven by variable-speed motor, controlled from the burning deck. The slurry is pumped into this wheel case by the feed pumps and enters the mouth of the kiln through an inclined and protected cast-iron pipe. The inclination and rotation of the kiln carry the raw mix toward the lower or firing end of the kiln. The slurry water is first evaporated, then toward the center of the kiln the limestone is calcined, leaving free lime and clay in intimate contact. The "sintering" or chemical combination of these occurs as the material approaches the flame, forming the clinker. This is in the form of dark gray or black vitreous nodules which can be stored in the weather and do not possess the property of cement until finely ground.

On the burning deck, back of and 18 in. below the bottom of the lower end of the kiln, are placed the hoods, which inclose the exposed lower ends of the kilns, the gas or oil burners and their carriages, the air blowers and electric control panels and the gas meters and the recording pyrometers. An operator on this deck controls the feed of fuel and air and the speed of rotation.

*Clinker*—The clinker, at a temperature of 2,000 deg. F., falls from the end of the kilns through holes in the bottom of the hood and deck into small lined pits and thence by short chutes into the coolers. These are steel drums 10 ft. in diameter by 100 ft. long, extending under and beyond the burning deck. They are lined in the upper end with firebrick, then with cast-iron plates and lifting tumblers. The coolers are mounted and rotate similarly to the kilns but at 1½ r.p.m.

The blowers draw warm air to the extent of only about 20 per cent of the total requirements for combustion, and it is mixed with the gas or oil fuel in the burner to aid in its ignition. The remainder of the air for the combustion is drawn by the stacks from the outlet end of the coolers, thus preheating the air for combustion and at the same time reducing the temperature of the clinker to 150 deg. F. The clinker falls from the coolers into a pit in the storage structure, whence the crane distributes it to the clinker storage and delivers either directly or out of storage to the finish mill feed bins.

*Finish Mills*—The two finish mills are essentially identical with the raw grinding mills, and the clinker and gypsum are fed by table feeders, smaller but of similar type to those described for the raw grinding mills. The finish grinding mills are ventilated by dust-collecting fans. The finished cement falls from the mills into a screw conveyor, which delivers it, together with the returned fine cement from the dust collectors, to either of two dust pumps. These blow the output through a 5-in. transport pipe line across tracks and roadway to one end of the storage structure, up and over its roof, and finally distribute it by means of a series of valves to any of the seventeen bins.

The stock house, with a capacity of 153,000 bbl., consists of two rows of seven silos, 24 ft. in diameter, separated 16 ft. clear by two smaller end bins and thus inclosing a large central bin which holds 46,000 bbl. The silos have sloping bottoms and are emptied by screw conveyors in three longitudinal tunnels which traverse the structure. The silos are carried on a massive slab, heavily reinforced.

The pack house is a four-story structure adjacent to one end of the stock house. The conveyors from the stock house extend into a basement, where a system of chutes and a cross-conveyor enables cement from any bin to be delivered to either of two bucket elevators. These are carried and driven on the fourth floor, delivering the cement to screens and cross-conveyors on the third floor, which in turn deliver from either elevator to either of the two bins serving the packing machines or to a spout for loading bulk cement. On the fourth floor is a bag wheel for beating and cleaning returned sacks, and on the third floor are sorting tables served by a belt conveyor, sewing machines, bag tiers, etc. The remainder of the pack house affords storage space for new and returned paper and cloth sacks. All pack-house machinery is completely equipped with dust collectors.

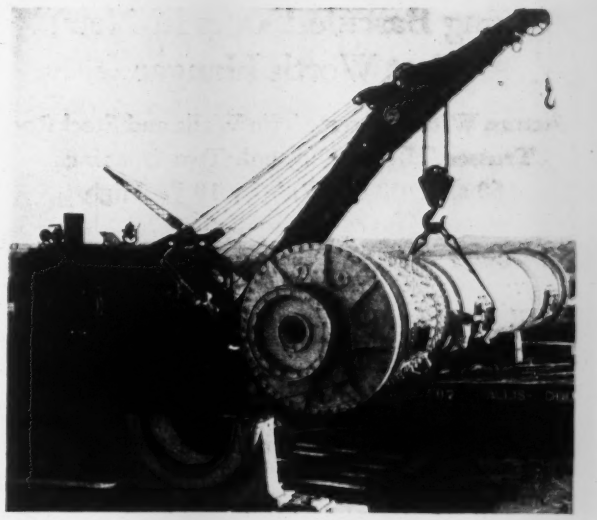


FIG. 6—MILLS WERE PLACED BY A LOCOMOTIVE CRANE

In addition to the main manufacturing structures, the plant embraces a service building for machine and electric shop, storeroom and locker rooms, 50x200 ft. in plan; an oil house; a pump house over the two wells which penetrate the artesian limestone and are pumped by well turbines; a 50,000-gal. concrete ground storage tank and an elevated steel tank of like capacity; an office building; a capacious laboratory with full facilities not only for routine chemical and physical tests but also for experimental tests on concretes, with mixing room, moist room and 300,000-lb. testing machine; a commissary building, all of concrete, steel, cement tile and stucco construction; and the employees' village, comprising some 56 residences.

The construction of the plant and erection of all equipment was carried out by the forces of Smith Brothers, Inc., general contractor, under the superintendence of A. F. Sayers. Subcontracts were let to the Bland Engineering Co., of Minneapolis, for the slip form construction of stock and pack houses and slurry tanks, and to the Heine Co. for the reinforced-concrete chimneys. The site was selected and tested, and the plant was designed throughout by the Terrell Bartlett Engineers, Inc., San Antonio, Tex., with R. K. Meade & Co., of Baltimore as consultants. Joah Etchells was principal assistant engineer on designs, and Alexander M. Erskine was resident engineer on the construction. The product of the plant under the brand name of "Longhorn" has been on the market since July, 1929.

# Long Bascule Doors in New Fort Worth Hangar

## Structure With Concrete Tile Walls and Steel Roof Trusses Entered Through Two Openings 60 and 100 Ft. Wide by 18 Ft. High

By C. Milo Thelin

*Designing Engineer, Department of Engineering, Fort Worth, Tex.*

THE AIRPLANE hangar recently constructed at the municipal airport by the city of Fort Worth, Tex., embodies several interesting features from the standpoint of design and convenience in handling airplanes, and is an example of the general trend toward more permanent structures for the aviation industry.

The construction is of skeleton steel with concrete tile walls covered on the outside with portland cement stucco. Fig. 1 shows the location with respect to the field and existing hangar and also indicates the proposed plans for future enlargement of the field and its facilities. The floor plan in Fig. 3 shows the general dimensions and details. The side of the building faces the flying field and is composed of the two doors, providing clear openings of 58 ft. 11 in. and 98 ft. 10 in. respectively, with 18-ft. vertical clearance. This location of doors permits the handling of planes with a convenience not obtained in large hangars with doors at the ends. The doors are of the bascule type of structural steel covered with 26-gage copper-bearing corrugated metal and include steel sash as shown in Fig. 2. The doors are supported by steel trusses and are readily operated by one man.

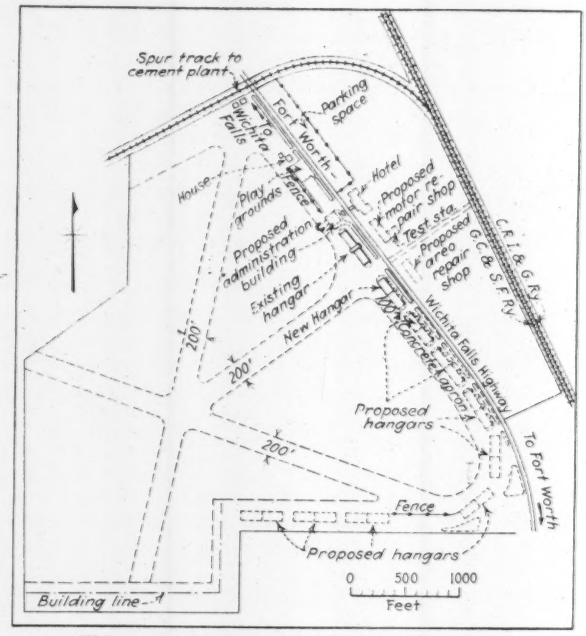



FIG. 1—LAYOUT OF FORT WORTH, TEXAS, MUNICIPAL AIRPORT

The 12-in. tile walls are 30 ft. high at one end and 26 ft. high at the sides of the building. They are carried on 24x24-in. concrete tile pilasters spaced at 20-ft. centers and in addition are anchored to the steel columns by means of ½-in. bolts with adjustable nuts. The pilasters are reinforced with two ¾-in. steel rods extending through the inside corner cells of the tile from top to bottom and anchored into the foundation. The

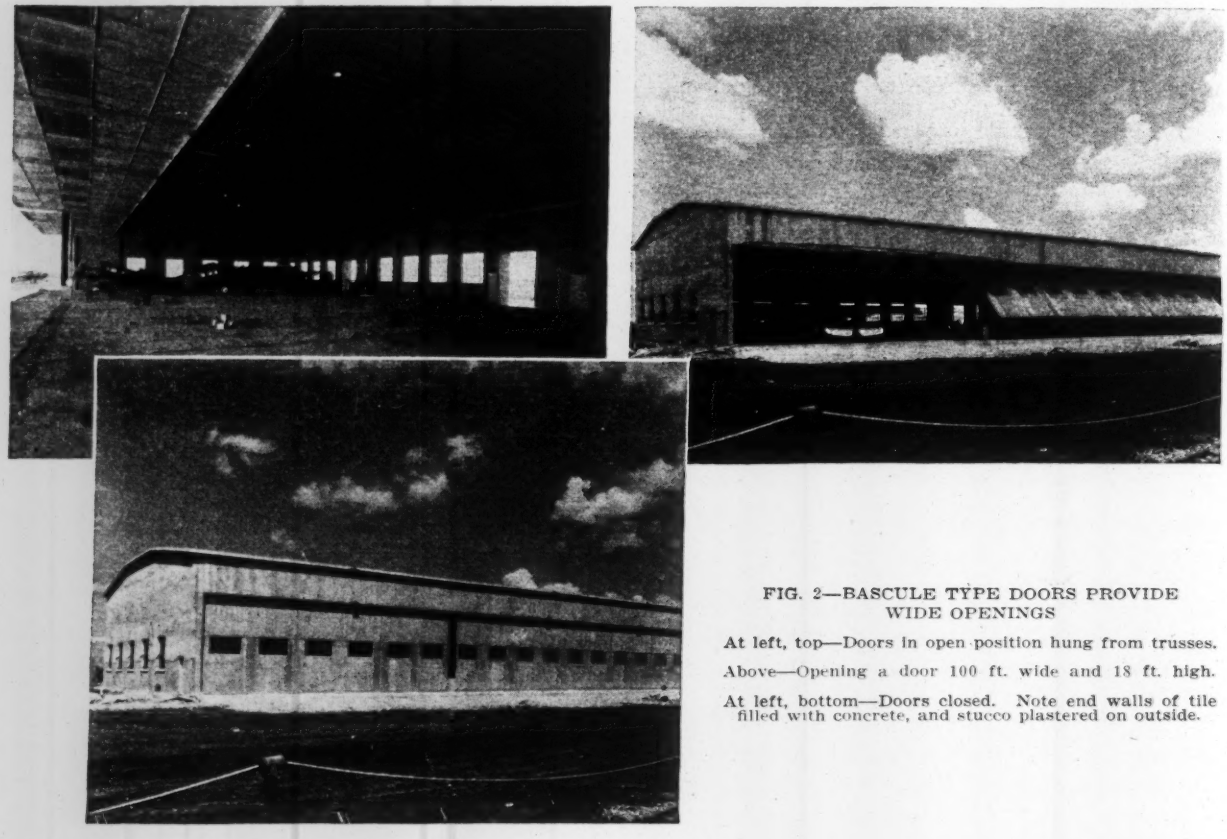


FIG. 2—BASCULE TYPE DOORS PROVIDE WIDE OPENINGS

At left, top—Doors in open position hung from trusses.

Above—Opening a door 100 ft. wide and 18 ft. high.

At left, bottom—Doors closed. Note end walls of tile filled with concrete, and stucco plastered on outside.

cells were filled with concrete as the pilasters and walls were constructed. One row of "trough" tile was placed 15 ft. up from the floor and another row at the top of the wall, each reinforced with two ¾-in. rods and filled with concrete. The concrete tile measured 5x8x12 in. and tested 1,200 lb. per sq.in. gross area. The foundation, which is reinforced, was carried down to rock at a depth of about 2½ ft., and the pilaster and column footings were carried down an additional 12 in.

The entire floor of 12,480 sq.ft. is constructed of 5 in. of concrete reinforced with 30 lb. per 100 sq.ft. of welded fabric. A 5-ft. concrete apron similarly reinforced extends out in front of the steel doors.

The south end of the hangar is constructed of 26-gage corrugated metal and structural steel bolted together so as to be removed for future addition. The roof has a timber deck and is covered with a built-up roofing composed of one 30-lb. and two 15-lb. sheets of roofing felt, and one 37.5-lb. cap sheet.

The complete structure, including a toilet and electric lights and receptacles, cost $25,930.70, or approximately $2.08 per square foot of floor. The cost of plans and specifications was 1.7 per cent of the total cost. The general type of structure is similar to the existing hangars as designed by Wyatt C. Hendrick, Inc., local architects. The plans and specifications were prepared by the writer under the supervision of D. L. Lewis, city engineer. O. E. Carr is city manager and W. G. Fuller is manager of the airport. Ellsworth Long was the general contractor. The city bond issue, approved June 25, provides $500,000 for additional buildings and facilities indicated in Fig. 1.

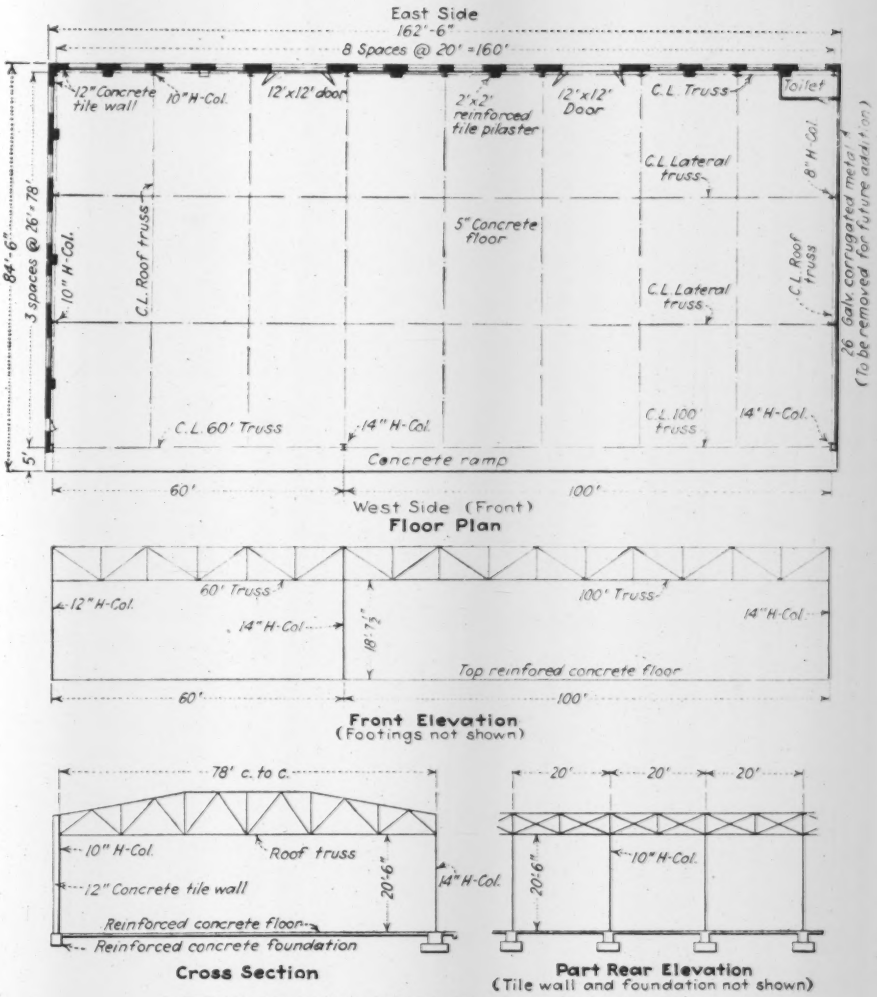



FIG. 3—PLAN AND SECTIONS OF NEW HANGAR, FORT WORTH AIRPORT

## Old Boundary Monuments

TROUBLES incident to the determination of boundary lines by old and perhaps missing monuments are noted in a paper presented before the Illinois Society of Engineers by W. D. Jones, land surveyor, of Chicago. This paper, of which an abstract is given below, indicates the importance of preserving such monuments or marking their locations by witness points.

A boundary line is created or was created by monuments set to mark its location. The whole question of a property line survey is: Where was that monument or what is the best evidence as to where it was?

The monuments set a hundred years ago, more or less, which created the section corners and quarter-section corners were then supposed to be permanent. If the charcoal set to create the corners had not been disturbed it would be in place today, and if the witness trees had not been cut they would nearly all exist today. What monuments exist for the section and quarter-section corners in and around Chicago are usually of stone. When sewers are constructed these monuments are taken out. It would be useless to replace them in the backfill, as they would settle out of position. Sewers are not needed, however, until subdivisions have been made and new monuments set for lot corners which form witness monuments for the section corners.

Destruction of property line monuments by concrete road construction is serious, because the roads are built where witness monuments have not been set. The engineer on construction may not realize the importance of the monuments and may fail to preserve them or to make either a private or a public witness. A land surveyor ought to be employed to witness and preserve or replace all property line monuments (which are often also county and state line monuments) along any highway construction. The U. S. government should require this, since the government created not only the state lines but also the section and quarter-section lines.

Every one knows that land surveyors frequently disagree. But very few know that in general the cause of the disagreement is not inaccuracy of present measurements but difference in judgment as to what is the best evidence of the original location of the monuments which created the corners and boundary lines. Probably the most common question asked of a land surveyor is, "Where do you get your starting point?" When the surveyor knows his starting point, his survey is practically completed.

TYPICAL LOUISIANA SWAMP ROAD EMBANKMENT AND BRIDGE

# Highway Fills Across Swamps in the Louisiana Delta

## Muck Overlying Clay Is Core-Trenched and Refill Land Embankments Are Made From Clay Dredged From Parallel Canals

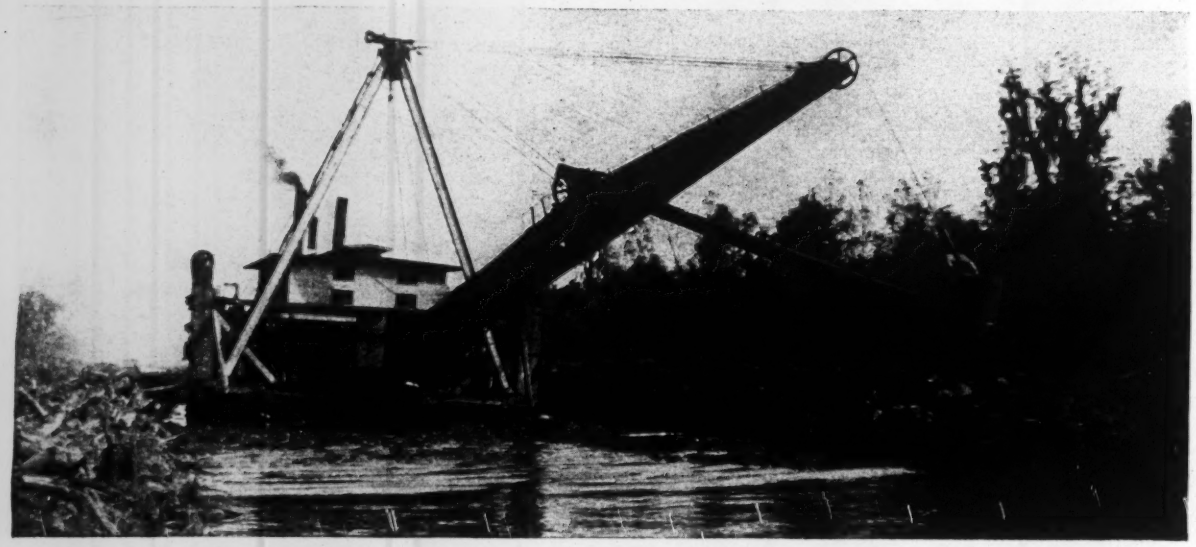
By H. B. Henderlite and John J. Mundinger

*State Highway Engineer and Consulting Engineer, Louisiana Highway Commission, Baton Rouge, La.*

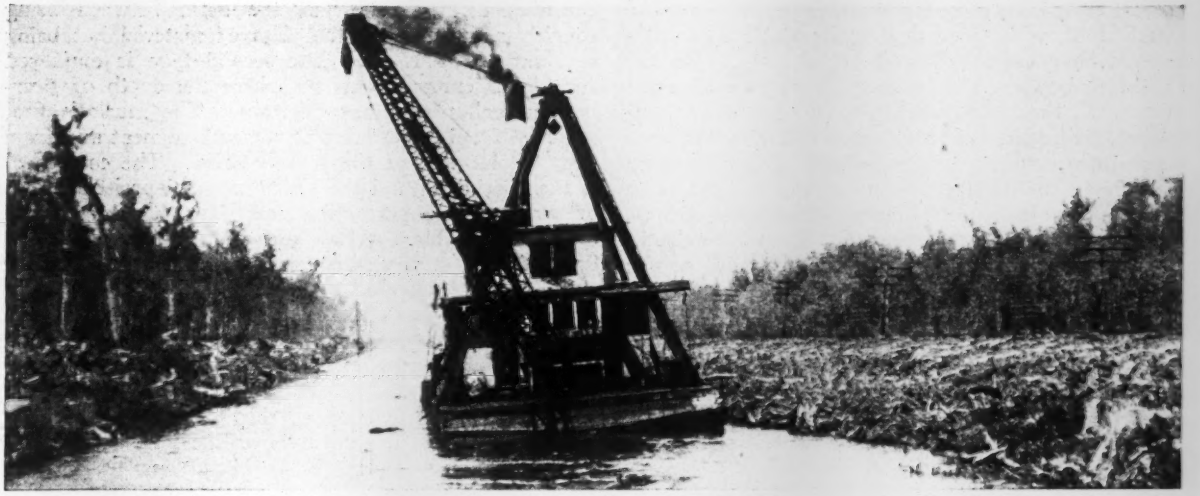
TOPOGRAPHY, drainage and character of available material have determined a type of road construction peculiar to the delta region of Louisiana. The roads through this swamp and bayou country are embankments built by dredge, of borrow from a parallel drainage canal. Generally speaking, the construction problem is paramount; the engineering is exceptional only in its extension to rather particular topographic and hydrographic surveys and to soil surveys chiefly to determine depth of stable material under the swamp and marsh muck.

*Topography and Subsurface Conditions*—The drainage system of the Louisiana delta is peculiar. In an area included within a radius of 50 miles of New Orleans and extending from the Gulf up the west side of the Mississippi River for 150 miles in a belt of the same width, the streams for half the year below the level of the Mississippi flow independent of but parallel to the Mississippi and consist of a tangle of intersecting bayous, sloughs and swamps.

The bayous do not lie in valleys or depressions with elevated areas between; instead, their channels are located upon ridges and between them the intervening areas are lower. They are lower in two ways: the swamp surface is very slightly lower and the solid bottom, which consists of a material not so finely divided but closely resembling clay, slopes away from the bayou under a blanket composed of the clayey material itself mixed



DIPPER DREDGE PLACING FIRST LIFT OF EMBANKMENT



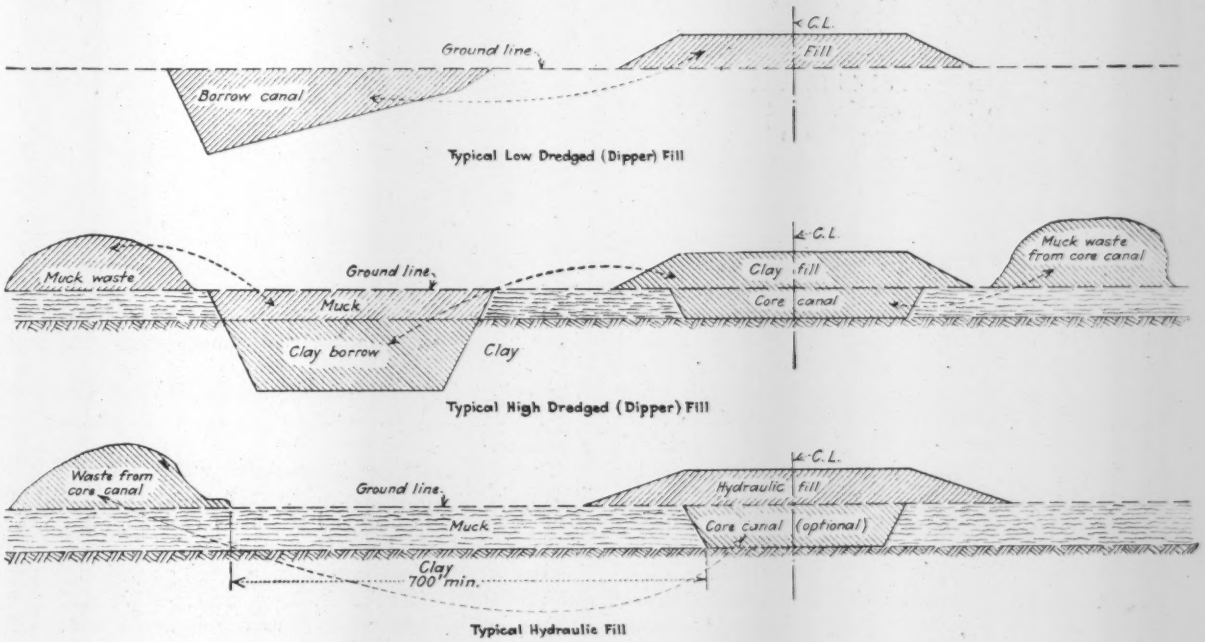
CLAMSHELL DREDGE PLACING SECOND LIFT OF EMBANKMENT

in differing proportions with muck and with a finely granulated organic débris locally known as "coffee grounds." The swamp muck overburden, which varies in depth, is heavily timbered with cypress, tupelo and gum. On the elevated areas along the bayous, especially in that district lying west of New Orleans, resides the densest rural population of the United States.

*Road Development*—In early days communication was solely by water, but meandering roads along the bayous were gradually improved and still are of local importance. Only in recent years have the parishes, together with the state, become financially able to employ modern machinery to construct embankments across the swamps. Such embankments are very expensive, because their construction requires the heaviest of dredges. The cost of embankments under 10 ft. above swamp level varies from $25,000 to $100,000 per mile. As an example, the set of bids that was received for a 2-mile approach to the Chef Menteur bridge, across an unwooded prairie a few feet above the level of the Gulf, ranged from $244,000 to $431,000. This embankment was about 5 ft. above ground level and was 60 ft. wide.

*Location Practice*—The location of swamp embankments is determined by a compromise between the importance and appropriate cost of the general route and the difficulties encountered in the specific swamp section being considered. As a rule, there is very little to choose between the locations through any particular swamp, within the limits fixed by the general route, and therefore the locations are usually tangents. Investigations are made by probings and wash borings, but the object is to determine the type of construction by learning the stability and depth of the overburden, rather than to fix the location.

*Design and Construction*—The stability of the material in embankments, disregarding water in motion, is a function of the proportions of organic matter present. On one extreme, embankments constructed of "coffee grounds" will support no great traffic density, as the vibration causes them to shrink, flatten out and subside,




TYPES OF SWAMP ROAD EMBANKMENTS IN THE LOUISIANA DELTA

and occasionally such material, which weighs about 15 lb. per cubic foot, will, when dry, ignite and burn. Embankments have been destroyed in this way. On the other extreme, when clayey material can be obtained from beneath the overburden, a very satisfactory embankment can be constructed, though several years must elapse before assured stability occurs. In all swamp fills, water is continually present in the borrow canal and in considerable quantities in the embankment proper, both because of capillary action and, even in embankments constructed of clayey material, because of the intrinsic affinity for moisture of humic, ulmic and other organic acids which are always present.

While the wide range of varying conditions prohibits a stereotyped classification, two general types of operations for constructing swamp embankments have developed. The first type, as illustrated, is employed when a low embankment is adequate or where the clayey material has practically no overburden. When the borrow canal is excavated rather close to the toe of the embankment, the line of the bottom of the canal when projected should intersect the nearer shoulder of the embankment, the width of the berm between being roughly a function of the class of material but being a minimum of 15 ft. The second type is employed for higher embankments or where the depth of overburden makes subsidence certain. The muck is first removed from the location of the embankment and from over the location of the borrow canal. The core canal is then backfilled and the embankment deposited in two or more layers, permitting each layer to dry out as much as possible. When a crust has formed on the embankment, it is shaped and leveled by drag line or a heavy blade machine.

The views illustrate the operations. One shows a dipper dredge depositing the first layer of material on the embankment; the stripping—a mass of roots, stumps and muck—appears at the left. Another shows a clamshell dredge depositing the second layer of the embankment, and the third shows the finished embankment. Drainage structures are numerous in this type of construction, and as the headroom is restricted, the structures must be long. Creosoted timber bridges and multiple box culverts are the logical structures.

# End Bearings of Bridge Allow for Shifting of Abutments

## As Banks of Red River May Carry Abutments Forward, Trucks Under the Trusses Permit Free Movement

BRIDGE expansion bearings which provide for possible extensive shifting of abutments in unstable ground as well as for normal expansion and contraction of the truss spans form a feature of exceptional interest in the new Sorlie memorial highway bridge built jointly by the states of North Dakota and Minnesota across the Red River between Grand Forks, N. D., and East Grand Forks, Minn. One of these truck bearings is shown in Fig. 1. The bridge (Fig. 2) consists of two 279-ft. through truss riveted spans on concrete abutments and a concrete pier. Its trusses, spaced 44 ft. c. to c., have a midspan depth of 45 ft. c. to c. of chords and are divided into 31-ft. panels. A total width of 60 ft. includes a 40-ft. roadway and two 7-ft. sidewalks on cantilever brackets, all paved with concrete. The floor is about 3 ft. above high water and 51 ft. above low water.

*Abutments in Unstable Ground*—Piers built in the channel of the Red River are said to be almost universally stable, while abutments on the banks are likely to be shifted or pushed forward owing to constant movement of a deep clay formation. This movement is considered to be a flowing rather than a sliding motion, as test borings have not disclosed any stratification or planes on which sliding might occur. Rock or other firm foundation is at too great depth to be reached, except at prohibitive cost. A swing span on a center pier was the main part of the old bridge, but steamboat service on the Red River ceased about 1910, owing to the construction of railroads and highways, so that fixed spans were permissible for the new bridge. The old stone center pier was demolished and a new concrete pier of dumbbell section, with octagonal ends, was built close to its site, founded on timber piles 50 ft. long.

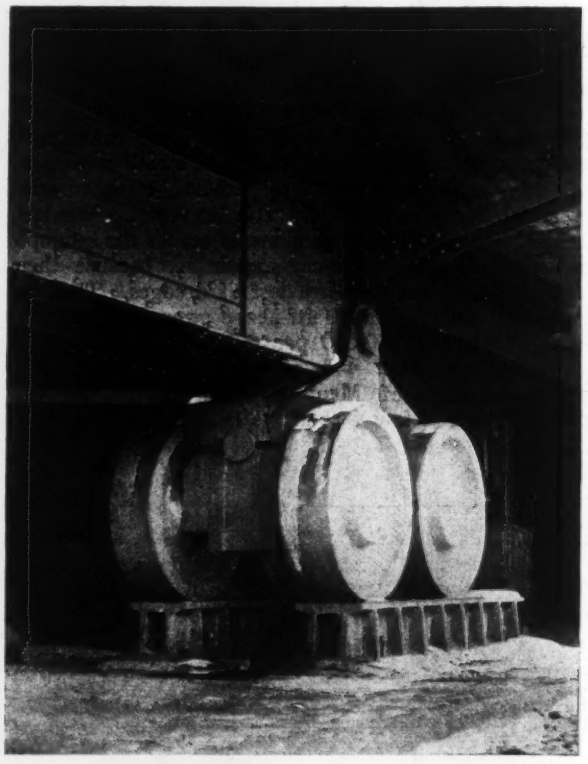


FIG. 1—TRUCK BEARING FOR GRAND FORKS BRIDGE

The ends of the pier are 7½ ft. in diameter under the coping and 11½ ft. at the base, on footings 20 ft. in diameter.

The abutments are bottomless concrete boxes having heavy side walls connected by a front and back wall and braced by inside diagonal members (see Fig. 2). Each side wall is 36 ft. long, 10 ft. wide and 8 ft. deep, forming the support for the expansion bearings and built upon 43 creosoted piles 70 ft. long, arranged in five rows. Those in the two outer rows are battered toward the river; those in the next rows are battered toward the

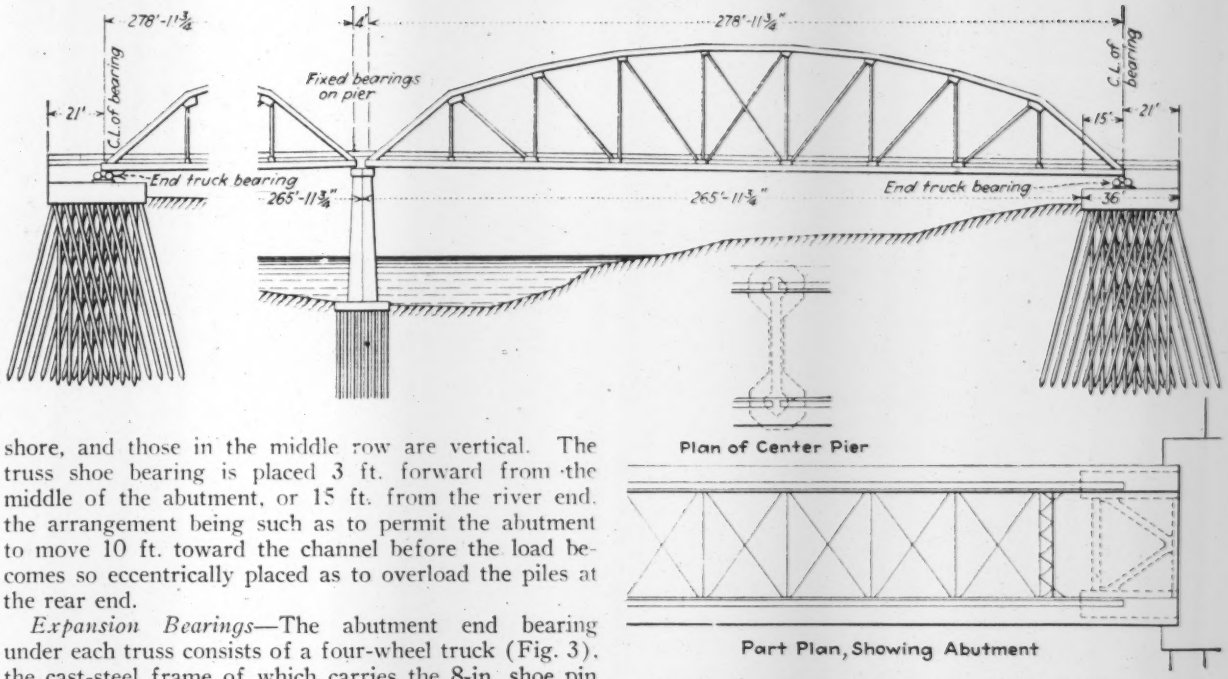



FIG. 2—RED RIVER BRIDGE AT GRAND FORKS, N. D. Note piling and bridge-seat trucks at each abutment to provide for slipping of riverbanks.

shore, and those in the middle row are vertical. The truss shoe bearing is placed 3 ft. forward from the middle of the abutment, or 15 ft. from the river end, the arrangement being such as to permit the abutment to move 10 ft. toward the channel before the load becomes so eccentrically placed as to overload the piles at the rear end.

*Expansion Bearings*—The abutment end bearing under each truss consists of a four-wheel truck (Fig. 3), the cast-steel frame of which carries the 8-in. shoe pin of the truss and is mounted on four 38-in. wheels having flat treads 10 in. wide. These wheels rest on a pair of base or track castings 7½ ft. long, anchored to the concrete cap of the abutment. The longitudinal travel on the track castings is limited to 2 ft., as it was considered that if the forward movement of the abutment should exceed this amount some adjustments in elevation and alignment would be necessary. To make such adjustments, the end of the span will be raised by jacks while the base castings are shifted back to position under the ends of the trusses. This unusual form of expansion bearing was adopted after study of different designs, on account of the large amount of movement permitted and the facility of adjusting it with the bridge end raised by jacks.

To provide for a 2-ft. movement of the abutment under the bridge, a sliding or telescopic joint is provided between the roadway of the bridge and that of the approach. From Fig. 4 it will be seen that I-beam stringers on the abutment carry a transverse member to which are attached 4-in. I-beam stringers 3 ft. long, covered by heavy deck plates. Corresponding 6-in. Z-bars, but staggered in relation to the I-beams, are supported at one end on the top flange of the end floorbeam of the bridge and at the other end by brackets cantilevered from the end floorbeam opposite the stringers. These brackets also support the ends of the approach stringers. The lower flanges of the Z-bars carry bearing plates for the ends of the approach I-beams. On the Z-bars is another deck plate which overlaps those covering the I-beams. Thus as the bridge expands under temperature changes or the abutment shifts under pressure the interlocking I-beams and Z-bars with their deck plates will telescope together.

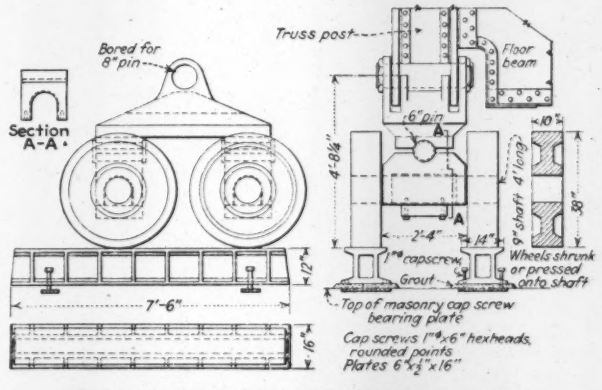



FIG. 3—TRUCKS FOR SHORE ENDS OF SPANS

*History of Grand Forks Bridges*—Historical interest attaches to this crossing of the Red River. A ferry was established in 1871 with a flatboat guided by a rope, but this was superseded by a pontoon bridge in 1878, except that the ferry was resumed during high-water periods. This bridge had several flatboats parallel with the current, but in 1879 another pontoon bridge was opened having a single 100-ft. flatboat moored across the channel and having pile trestle approaches. A suspended deck operated by cables provided for adjustment to the level of the fixed approaches at different stages of the river. When a steamer passed, one end of the boat was released and allowed to swing downstream, being pulled back by a cable and hoist. The Great Northern Railway completed its bridge in 1880, and the Northern Pacific Railway in 1887.

Two highway bridges were built by the city in 1889. The one at De Mers Ave., now replaced, consisted of a 222-ft. swing span with a fixed span of 90 ft. on each side, and timber trestle approaches. The other old bridge, at Minnesota Ave., of practically identical design, is still in use. A lump sum contract of $62,000 was let for the two bridges complete. They were at about the same elevation as the new bridge.

As an interstate project, extended negotiations had to be carried out for financing the new bridge, which was authorized by the North Dakota Legislature in 1927 with an appropriation of $75,000 and was designed by the state highway department. The Minnesota depart-

ment of highways indorsed the project, and under a state law of 1925 relating to bridges across boundary waters the department was authorized to expend trunk highway funds on this interstate bridge. Upon entering into the contract the Minnesota department of highways allotted $160,000 for this purpose, of which $15,000 was from the federal-aid funds granted to the state, while North Dakota applied 50 per cent of its federal-aid funds toward the cost of the structure. At first direct federal aid was refused because the bridge was not on a rural highway but was to connect the streets of two cities. This difficulty was overcome by an amendment to the federal-aid highway act which made the project eligible for assistance.

*Construction Progress*—When bids were opened in

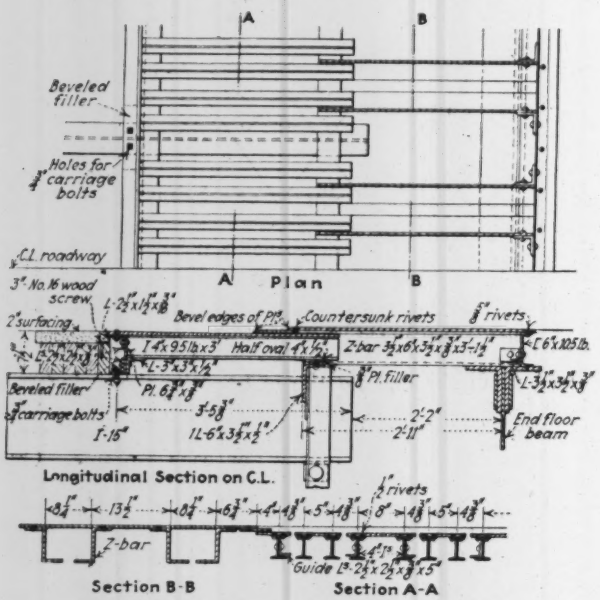



FIG. 4—SLIDING JOINT IN BRIDGE FLOOR
This provides for a 2-ft. movement of the abutment if shifted by the flowing bank.

1928, the lowest bid was $318,000, or $18,000 more than the amount available, but the city of Grand Forks guaranteed North Dakota's share of the excess amount and later the two states made up the sum of $30,000 for final completion. The total cost, including removal of old bridge, construction of temporary footbridge, paving approaches and all contingent work, was about $320,000.

The old bridge was closed to traffic on Nov. 30, 1928. A temporary low-level trestle or footbridge was opened Dec. 18, but from March 16 to May 1, 1929, it was useless on account of high water, a walkway being laid on the Northern Pacific Railway bridge during this period. Steel erection on falsework was begun June 21, the first span was swung clear of falsework on July 29 and the second span on Aug. 12. Concrete paving was completed Sept. 3, and pedestrian traffic permitted on Sept. 8, the bridge being formally dedicated and opened on Sept. 14. It is named in memory of the late Arthur G. Sorlie, governor of North Dakota and chairman of the state highway commission, who died in 1928.

*Engineers and Contractors*—The design for this bridge, including the novel expansion bearings, was made by Clifford Johnson, bridge engineer of the North Dakota Highway Department, under the direction of H. C. Frahm, chief engineer. These designs were approved by J. T. Ellison, chief engineer, and M. J. Hoffman bridge engineer, of the Minnesota Department of Highways; and by E. O. Hathaway, district engineer, and W. P. Linton, district bridge engineer, of the U. S. Bureau of Public Roads. R. M. Van Petten was resident engineer, representing the two states. The contractor was the Minneapolis Bridge Co., Minneapolis, Minn., with George F. McDowell as its superintendent.

# Vibration Effects on Foundations and Masonry Structures

## Buildings and Models Tested for Intensity of Earth Vibrations Caused by Traffic and Machinery

MINOR EARTH VIBRATIONS resulting from heavy street traffic, street cars, railroad trains, rotating or oscillating machinery, piledriving or blasting are of frequent occurrence in large cities, but there is little definite information as to their relation to the stability and settlement of structures. A review of the results of experiments on foundations and masonry buildings and of laboratory tests to determine the intensity and effects of such vibrations was presented at the annual meeting of the American Association for the Advancement of Science by C. C. Williams, dean of the college of engineering at the University of Iowa. Although the observations thus far are too limited to warrant more than tentative conclusions, an abstract of this paper is given here as of interest and value to the designers of buildings. —EDITOR.

VIBRATIONS transmitted through the soil from a focus of impulse are both vertical and horizontal, the latter being usually two or three times as great as the former. In a building, vibrations having an amplitude of 0.001 in. and a period of 0.1 second would be felt as a violent shaking. But the most severe earthquake on record had an amplitude of only about 2½ in. and a period of one second. The question naturally arises whether the lesser vibrations cause damage in proportion to their intensity.

*Observations on Vibration*—Dropping a 4-ton weight 46 ft. on firm limestone produced a vibration of 0.0003 in. at a distance of 450 ft. A 4-ton hammer driving piles in sandy soil produced a vibration of 0.0012 in. at 120 ft. Heavy blasting was found by Professor Rockwell, of Rutgers University, to give a maximum vibration of 0.01 in. with a frequency of ten per second at a distance of 1,500 ft. The writer's observations have indicated vibrations due to steam railroad trains to be about 0.005 in. at 25 ft. from the nearest rail. The intensity diminished with distance and practically disappeared at 150 ft. These vibrations caused slight settlement of loaded posts 25 ft. distant. Street cars caused a vibration approximately half as great. These vibrations were all measured at the surface by setting a vibrometer on iron pins driven into the ground.

*Cumulative Action*—That such vibrations became attenuated with distance and finally vanish is known, but their relations to the intensity of the impulse and the character of the soil are largely unknown. Moreover, the depth to which the vibration extends is unknown. In experiments at the University of Iowa it was observed that the rate of restitution was appreciably less than the

rate of travel of the impulse. This phenomenon, which can be accounted for by the time or hysteresis effect in compression of the soil, explains why vibrations cause pictures to become askew and vessels gradually to shift position on shelves. The impulse is sufficiently rapid to cause the inertia force to overcome friction, but the restitution is not sufficiently rapid to do so. Hence the shelf moves under the vessel in one direction but not in the other, and as a result the movement becomes cumulative. For example, the curator of the natural history museum at the University of Illinois found that his specimen jars gradually moved off the shelves due to vibrations from street traffic. Observation showed that heavily loaded trucks caused a vibration as much as 0.0004 in. but that ordinary traffic did not cause sufficient vibration to be measurable. This unbalanced character of impulses from vibrations transmitted through the soil is of importance in respect to foundations, because the movement tends to be cumulative.

*Tests on Building and Bridges*—The magnitude of vibrations communicated to a building from the earth through the foundations obviously depends upon the character of the building. Prof. E. E. Hall, of the University of California, measured vibrations in a reinforced-concrete substation and found that those caused by street traffic were greater than those caused by the motor-generator sets. Vertical vibrations on a balcony 50 ft. from the motor-generator were 0.0002 in. with a frequency of 8.6 per second; horizontal vibrations of the building were 0.0005 in. at 1.9 seconds. Street traffic caused vibrations of 0.0006 in. at 5 per second. A load of crushed stone passing over a cobblestone pavement caused vibrations at 0.0014 in., or about seven times that caused by the motor-generator set.

He reports another case of a 1,000-kw. horizontal turbo-generator set mounted on a steel frame connected to the reinforced-concrete walls of the substation. In an adjacent nine-story office building, with foundation walls in contact, the walls were found to be in vibration from top to bottom, the vibration being greatest at the bottom, passing a node of minimum amplitude at three-quarters the height and increasing again at the top. In the substation, the vibrations were about 0.002 in. vertical and 0.04 in. horizontal near the turbine on the floor. On the top floor of the adjoining building the transverse vibration was 0.004 in. with a frequency of fifteen per second. Professor Hall found the vibrations on the third floor of a brick building, caused by street traffic, to be 0.0014 in. with a frequency of about two per second.

Measurements taken in the Times Building, New York, as noted in *Engineering News-Record* of July 14, 1921, p. 60, showed a maximum vertical vibration of 0.004 in. at a frequency of fifteen to twenty, due to the passage of subway trains. Observations on top of bridge abutments and piers gave vibrations with amplitudes of 0.0005 to 0.005 in. due to passing steam trains. Prof. F. Omori, of Japan, found that on top of a pier 82½ ft. high, supporting a 200-ft. railway bridge, the maximum vibration parallel to the track was 0.042 in., with a light train moving 9 miles per hour. The transverse vibration was about half as great. On an arch bridge of the open spandrel type, carrying street traffic, at Danville, Ill., vibrations of 0.007-in. vertical amplitude were caused by a passing truck.

*Effects on Structures*—What effect do such vibrations have in the deterioration of masonry structures and in causing foundations to settle? Consider a 12-in. brick basement wall 12 ft. high. If the inertia of the floor and of the upper stories is assumed to hold the top of this wall stationary while the bottom is moved 0.006 in., the fiber stress at the top (calculated as a cantilever) would be slightly less than 2 lb. per square inch, which is too small to overstress the material or even to affect the endurance limit in fatigue. Suppose the wall is subject to a vertical vibration of 0.003 in. with a frequency of ten per second. Assuming a compressive stress in the masonry of 500 lb., the calculated additional stress is about 10 lb. That is, the stress would vary from 490 to 510 lb. in each period of the vibration, a range which would not be expected to injure the masonry by fatigue or otherwise.

*Laboratory Tests*—The writer set up a vibratory table on which brick piers were vibrated with the amplitude and frequency caused by street traffic, trains and rotating machinery. Piers 12 in. square and 4 ft. high, vibrated for 24 to 48 hours, showed no diminution of compressive strength as compared with duplicate specimens not vibrated. As the strength of brickwork in compression does not depend upon adhesion, this result might logically be expected. Piers vibrated while the mortar was green showed a distinct increase in compressive strength, due doubtless to the better embedment of the bricks caused by the vibrations.

Small specimens consisting of three bricks in mortar, with weights on them to produce anchorage by inertia, were vibrated in a similar manner. These were tested in shear by pushing the middle brick from between the two outside bricks, and a diminution in shear strength was noticeable in some cases. This effect may become apparent in brickwork over door and window openings, where the mortar joints may be subjected to shear and tensile stresses.

A large box containg compacted soils was placed on the vibratory table and a small area was loaded by a bearing plate. After the plate had settled the table was vibrated with an amplitude of 0.005 in. and frequency of ten per second. In every case the vibrations caused settlement, the amount depending upon the soil. Bearing blocks loaded eccentrically tilted farther due to the vibraitons, the amount varying with the nature of the soil. Model piles 10 in. long, 8 in. center to center were driven into the compacted soil. After settlement under load had ceased, these foundations were vibrated and considerable settlement occurred.

*Results and Conclusions*—The settlement of foundations in these observations was especially noticeable in plastic soils and almost negligible in sand. The explanation is that on plastic soils any considerable load causes settlement, and when this ceases, the equilibrium between load and resistance is rather delicately adjusted, so that any increase in the effective load will cause further settlement. In most soils this probably would not be large, because with the increased compression the supporting capacity increases. Although the observations are far from being exhaustive, the following conclusions are indicated: (1) The bearing capacity of masonry walls and piers is not affected appreciably by minor vibrations transmitted through the earth. (2) Where brick masonry is under shear along the joints, the strength is probably impaired by such vibrations. (3) Buildings founded on plastic soil, such as most brick buildings up to four stories, may be expected to settle somewhat when subjected to vibrations of the magnitude caused by the passing of heavy street traffic or of railroad trains.

# Preliminary Studies and Control of Concrete on Port of New York Authority Work

## Preliminary Tests and Careful Proportioning Yield 400,000 Cu.Yd. of High-Quality Concrete—Details of Procedure on First Contract—Designed for 2,500 Lb. at 28 Days, Two-Year Tests Break at 3,690 Lb.

By A. W. Munsell

*Engineer of Masonry Inspection, Port of New York Authority*

THE large volume of concrete involved in the projects of the Port of New York Authority is of particular interest because of the careful methods by which it was proportioned and tested and because of the high quality obtained. The Hudson River suspension bridge between Fort Washington, N. Y., and Fort Lee, N. J., and the Kill van Kull steel arch bridge between Port Richmond, Staten Island, and Bayonne, N. J., will require the placing of approximately 400,000 cu.yd. of concrete. The quality of this concrete, if it is to meet present-day specifications, can be obtained only by methods of control that will deliver specified mixtures, both of water and aggregates, that are found by preliminary studies of the materials to be necessary. This paper in the main describes the methods used in the laboratory for fixing the proportions and mixes. During the progress of the work other tests were made in the field. At the conclusion of the work it was therefore possible to make a close comparison between estimated and actual results.

Preliminary laboratory tests are made on all contracts as soon as the source of the cement and aggregates are known. The tests made for the concrete involved in the New Jersey tower bases of the Hudson River bridge, in which 34,000 cu.yd. of concrete was placed, are given in detail as an illustration of the methods followed on all subsequent contracts of the Port Authority. The problem of obtaining the strength of the concrete, the grading of the aggregates and the consistency of the concrete as fixed by the requirements of the specifications is outlined in the following.

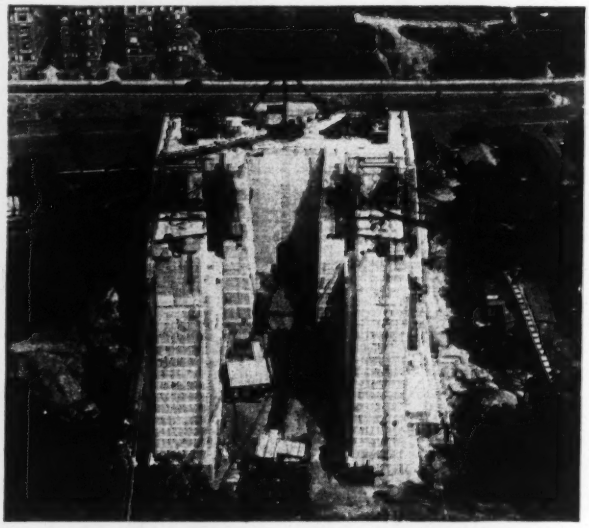


FIG. 2—NEW YORK ANCHORAGE OF HUDSON RIVER BRIDGE
110,000 cu.yd. of concrete proportioned in plant at right of anchorage.

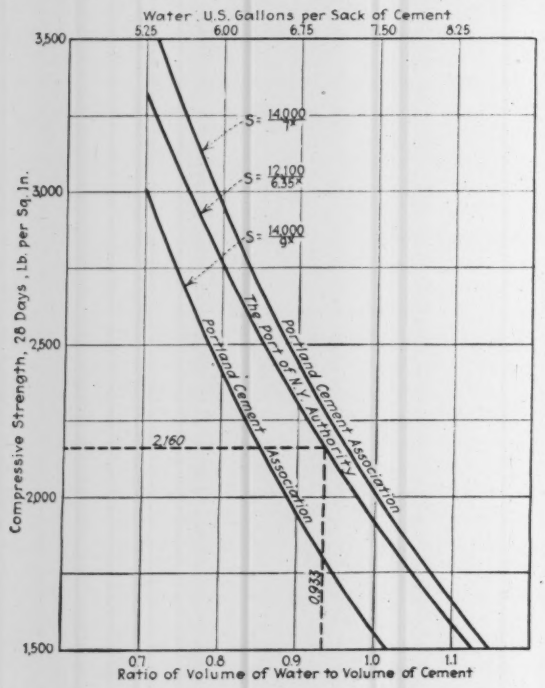



FIG. 1—WATER-CEMENT-STRENGTH CURVE FOR MATERIALS USED ON NEW JERSEY TOWER BASES FELL BETWEEN *A* AND *B* CURVES OF PORTLAND CEMENT ASSOCIATION

### *Preliminary Laboratory Tests*

A minimum strength of 2,000 lb. per square inch, using not more than 7 gal. of water, including the surface moisture of the aggregates, with a usual slump of 2 in. but not more than 3 in. was specified. The object of the preliminary studies was: (1) to obtain data as to the changes in strength where the ratio of the water to the cement was varied; (2) to determine how the grading of the aggregate affected the workability, and what grading of the aggregates limited the workability of the resulting concrete; (3) to determine the most economical mix that would give the desired consistency with the safe minimum strength required by the specifications.

*Test Methods*—Coarse aggregate was separated into several sizes, and that used in making each concrete specimen was recombined to meet a predetermined sieve analysis. The fineness modulus was kept constant at 7.5. The fineness modulus of sand was also kept constant at 3.0 by the addition of varying amounts of grits. Finally, the sand and gravel were mixed so that the following values of fineness modulus of the mixed aggregates were obtained: 5.2, 5.4, 5.6, 5.8, 6.0 and 6.2. The weights per

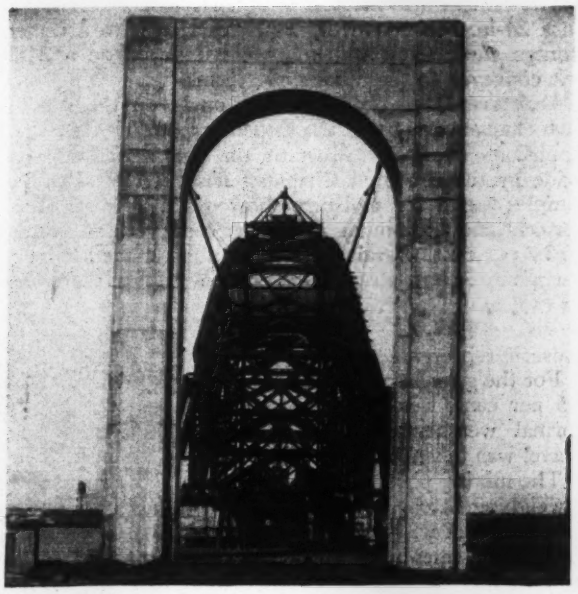


FIG. 3—ONE OF THE APPROACH PIERS, KILL VAN KULL BRIDGE

cubic foot of these different mixed aggregates were determined, and these weights used in computing the volume of mixed aggregates in each batch. The unit weight of sand was 106.5 lb. per cubic foot and of gravel 116 lb. per cubic foot. Both the fine and the coarse aggregates were in a room-dry condition—that is, with the absorbed moisture retained.

In molding the cylinders, the mixture having the desired fineness modulus was added to a cement paste of the water-cement ratio for this particular cylinder until the desired consistency was obtained as measured by the slump test. Any excess concrete over that required for one cylinder was placed in another cylinder and the volume of this concrete used in computing the actual yield. After being allowed to stand for two or three hours the cylinders were capped with a thin layer of stiff neat-cement paste, and in 24 hours were removed from the molds and stored under damp sand until the day before they were to be broken.

For each different fineness modulus of mixed aggregate, five cylinders were made for each of the five water-cement ratios. Two of each set of five cylinders were broken at the age of seven days. The three other cylinders of the set were broken at the age of 28 days.

All of the usual calculations for real mix, nominal mix, number of bags of cement per cubic yard of concrete, etc., were made. The computed 28-day strength based on the seven-day result proved to be in excess of the actual 28-day strength for the same water-cement ratios. Variation was the greatest with the high water-cement ratio and decreased as the water-cement ratio grew smaller. Because of this variation, actual 28-day strengths were used in computing the equation showing the relation between the strength and water-cement ratio. The curve of this equation was found to fall between the *A* and *B* curves of the Portland Cement Association as shown in Fig. 1.

A chart (Fig. 4) was plotted to show the relation between the real mix, the number of bags of cement per cubic yard of concrete and the fineness modulus of the mixed aggregate. The maximum permissible fineness modulus of the mixed aggregate, shown on this chart, limits the ratio of the fine to coarse aggregate. For higher values of fineness modulus than the maximum permissible value, the concrete could be made workable, but a greater slump than that desired was usually the result.

*Conclusion*—Seven gallons of water per bag of cement, as specified, gave a water-cement ratio of 0.93. According to Fig. 1, this corresponds to a strength at 28 days of 2,160 lb. From Fig. 4 it is evident that the fineness modulus of the mixed aggregate is 5.84, the real mix for a 2-in. slump is 5.10, and the number of bags of cement required per cubic yard is 4.9. The 5.10 parts of mixed aggregates would contain 2.18 of sand and 3.76 parts of gravel, measured in a dry-rodded condition. Taking into account the bulking (average 20 per cent for damp sand and 10 per cent for damp gravel) the mix measured by loose volume in the field should be 1 cu.ft. of cement, 2.59 cu.ft. of sand and 4.14 cu.ft. of gravel.

The specifications, however, require that the aggregate be measured by weight, and the mix, on this basis, is one bag of cement, 232 lb. of sand with zero surface moisture, 436 lb. of gravel with zero surface moisture, and 7 gal. of water. However, an average of 3 per cent surface moisture for the sand and 1 per cent for the gravel was found to be average, so that after corrections were made for this, the mix estimated to be proper for the materials available was one bag of cement, 240 lb. of damp sand, 440 lb. of damp gravel, and 5.6 gal. of water.

The 28-day field tests performed on 105 test cylinders designed for a strength of 2,160 lb. per square inch and on five test cylinders designed for 2,260 lb. per square inch showed that for the former 84.8 per cent were within 20 per cent of the average strength of all test

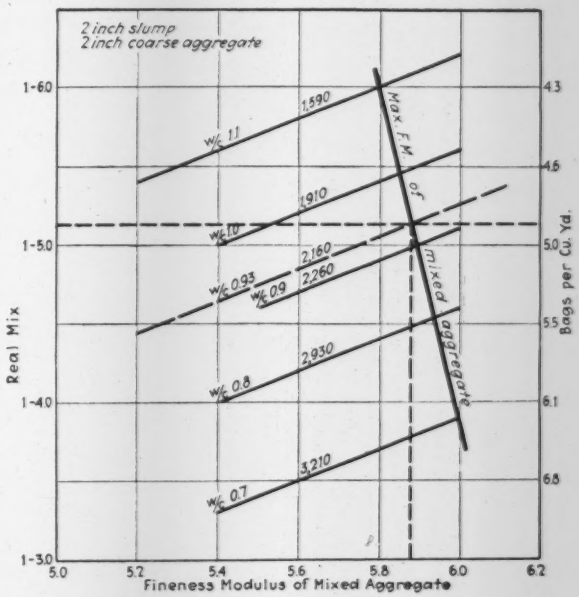



FIG. 4—REAL MIX AND CEMENT REQUIRED FOR VARIOUS FINENESS MODULI OF TOTAL AGGREGATE IN NEW JERSEY TOWER BASES

cylinders, and for the latter 100 per cent were within 10 per cent of the average. In Fig. 5 are shown the 28-day test results of the cylinders designed for a strength of 2,160 lb. The close comparison between specified and actual results is shown in the following table:

| | Proportions | | Slump, | Strength, | Water, | Bags Cement Per |
|---|---|---|---|---|---|---|
| | Dry and Rodded | Damp and Loose | In. | Lb. | Gal. | Cu.Yd. |
| Recommended | 1:2.18:3.76 | 1:2.59:4.14 | 2 | 2,160 | 7 | 4.9 |
| Actual..... | 1:2.18:3.80 | 1:2.65:4.20 | 2 | 2,200 | 7 | 4.95 |

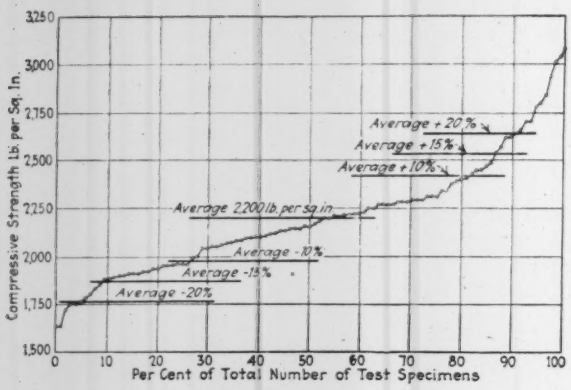



FIG. 5—COMPRESSIVE STRENGTH OF FIELD-MADE CYLINDERS AT 28 DAYS, ARRANGED IN ORDER OF ASCENDING STRENGTH FOR CONCRETE USED ON NEW JERSEY TOWER BASES

Tests of the concrete from the field, extending over long time periods, have given the following results:

| Age | Number of Test Pieces | Unit Strength Lb. Per Sq.In |
|---|---|---|
| 28 days | 105 | 2,200 |
| 3 months | 34 | 2,900 |
| 6 months | 26 | 2,790 |
| 1 year | 4 | 3,230 |
| 2 years | 3 | 3,690 |

The most important fact to be noted from these comparisons is that the amount of cement used per cubic yard of concrete was 4.95 bags, based on 34,458 cu.yd. placed, or only 0.05 of a sack more than was estimated from the preliminary tests. Also, as ordinarily specified, 2,000-lb. concrete requires a proportion of 1 : 2 : 4 with 5.8 bags of cement per cubic yard. On this work an average strength of 2,200 lb. was obtained with a 1 : 2.65 : 4.20 mix, using 4.95 bags per cubic yard. The saving of 0.85 of a bag of cement for each yard of concrete represented 51c. per yard with cement at 60c. per bag; on the total of 34,458 cu.yd. placed, the saving was $17,573.58.

*Field Methods*—Special attention was given to the instruction of inspectors, inasmuch as this was our first experience in proportioning by weight instead of by volume or inundation. A field laboratory was equipped on the site. The aggregates were received in barges, each barge loaded one-third sand and two-thirds gravel. They were unloaded with a clamshell bucket, emptying into a hopper over a 30-in. conveyor belt, leading to the boot of a bucket elevator which discharged into hoppers over the weighing batchers.

The cement also arrived in lighters and was unloaded on a 24-in. belt conveyor, which carried it to a cement storage shed, from which it was conveyed on a 24-in. belt conveyor to the mixing platform.

Moisture determinations were made on the sand at each change of shift of the inspectors and oftener where conditions required. Most of the determinations were made by the use of a Chapman flask. A total of 106 samples tested for moisture showed a maximum of 5.5 per cent and a minimum of 2.5 per cent, with an average of 3.7 per cent. Parallel determinations, made by drying out a sample on a steam radiator, showed that there were no radical differences between the results; the flask was therefore used in a majority of the determinations because it represented a much faster method.

For the gravel the moisture content ranged from 0.5 to 2.5 per cent, with an average of 1.2 per cent. Under normal weather conditions the surface moisture for gravel was taken as 1 per cent.

The mixing plant consisted of a 2-yd. mixer served by a weighing batcher with a capacity of 10,000 lb. and an overflow tank with a capacity of 90 gal., equipped with a wheel adjustment for fixing the amount of water. The time of mixing was fixed at two minutes from the time all materials were in the mixer, and this time was controlled by a locking and timing device. Actually the timing device was set at two minutes and twelve seconds and the discharge chute was automatically locked until the proper time elapsed. The concrete was discharged into drop-bottom buckets of 2-cu.yd. capacity, which were conveyed on industrial cars on tracks constructed between the two tower bases, where the buckets were picked up by the boom of a stiff-leg derrick and dumped in the forms.

The excellence and uniformity of the concrete resulting from these control methods are partly shown in the summary of the results from seven contracts in which the data given by the preliminary tests are compared with the results of the tests obtained from the same materials taken in the field.

It will be noted that all of the ingredients of the concrete are variable except the water. All the materials were weighed either at central mixing plants or at central proportioning plants, except in the laboratory building, where the proportions were fixed by struck-off volumes, compensated for bulking in both aggregates.

In the strength results a maximum difference of 8 per cent is shown between the average strength of the preliminary tests and the average actual strength from the tests in the field. These results are from all test pieces,

SUMMARY OF RESULTS OF TESTS ON FIELD CONCRETE, PORT OF NEW YORK AUTHORITY
Age at Time of Test, 28 Days

| | Outerbridge Crossing Deck Slab | Goethals Bridge Deck Slab | Water, 6.5 Gallons Hudson River Bridge N. J. Anchorage | Kill van Kull Bridge Main Piers | Kill van Kull Bridge Bayonne Approach | Kill van Kull Bridge Pt. Rich. Approach | Laboratory Building | Average |
|---|---|---|---|---|---|---|---|---|
| Expected strength, preliminary tests | 2,900 | 2,900 | 2,680 | 2,730 | 3,050 | 2,850 | 2,760 | 2,840 |
| Actual strength from field | 2,910 | 2,980 | 2,850 | 2,910 | 3,070 | 3,100 | 2,810 | 2,950 |
| Variation from expected strength, per cent | +0.3 | +2.8 | +6.3 | +6.2 | +0.7 | +8.0 | +1.8 | |
| Variation from average of actual strength, per cent | 1.4 | 1.0 | 3.4 | 1.4 | 4.1 | 5.1 | 4.7 | 3.0 |
| Number of specimens broken | 47 | 42 | 31 | 112 | 93 | 86 | 22 | .... |
| Sacks of cement per cu.yd., preliminary tests | 6.35 | 6.35 | 6.20 | 5.46 | 5.90 | 5.96 | 5.85 | .... |
| Sacks of cement per cu.yd., actual tests | 6.30 | 6.40 | 6.30 | 5.30 | 6.01 | 5.63 | .... | .... |
| Variation from exp. cement, cu.yd., per cent | −0.8 | +0.8 | +1.6 | −2.9 | +1.9 | −5.5 | .... | .... |
| Slump, preliminary tests | 3.00 | 3.00 | 4.00 | 4.00 | 4.00 | 3.00 | 3.00 | .... |
| Actual average slump | 4.56 | 3.35 | 3.97 | 3.22 | 2.38 | 2.46 | 3.52 | .... |
| Recommended preparatory preliminary tests | 1-1.71-3.35 | 1-1.71-3.35 | 1-2.00-2.75 | 1-1.79-3.44 | 1-2.15-3.09 | 1-2.17-2.95 | 1-2.06-3.04 | .... |
| Actual preparatory average | 1-1.82-3.11 | 1-1.67-3.11 | 1-2.02-2.70 | 1-1.80-3.44 | 1-2.20-3.04 | 1-2.13-3.03 | 1-2.06-3.04 | .... |
| Recommended real mix | 1-4.20 | 1-4.20 | 1-3.87 | 1-4.46 | 1-4.24 | 1-4.13 | 1-4.38 | .... |
| Actual real mix, average | 1-4.00 | 1-3.88 | 1-3.82 | 1-4.46 | 1-4.24 | 1-4.18 | 1-4.38 | .... |
| Brand of cement | A | B | C | B & D | C | A | C | .... |
| Source of fine aggregate | No. 1 | No. 1 | No. 2 | No. 2 | No. 2 | No. 3 | No. 4 | .... |
| Source of coarse aggregate | No. 5 Cr. stone | No. 5 Cr. stone | No. 6 Cr. stone | No. 7 Gravel | No. 5 Cr. stone | No. 5 Cr. stone | No. 6 Gravel | .... |
| Cu.yd. of concrete placed | 11,315 | 9,260 | 16,303 | 33,067 | 14,724 | 15,380 | .... | .... |
| Sacks of cement used | 71,240 | 59,224 | 102,639 | 175,100 | 88,424 | 75,420 | .... | .... |

none being eliminated for any reason, although some individual tests could fairly have been discarded for poor sampling or poor workmanship in the test pieces. All results were taken as being representative of the whole mass. The difference between the average preliminary test strengths and the average field strengths is 90 lb., or approximately 3 per cent. The maximum difference in the preliminary tests is 370 lb., or 13.4 per cent and in the field tests 290 lb., or 10 per cent.

The economy in the use of cement to secure a safe maximum strength without waste is shown in the comparison of sacks of cement used per cubic yard of concrete, where the actual cement used over the expected was kept within 5 per cent of the quantity predicted, or 5 lb. in the cubic yard of concrete. Although some of these contracts used slightly less cement than was recommended, there was no aim to save cement over the quantity recommended for each contract. The large runs of concrete per day helped to save cement, as there was less loss caused by changing from one location to another.

FIG. 6—TESTING MACHINE ROOM, PORT OF NEW YORK AUTHORITY LABORATORY
50,000-lb. machine at left and 1,000,000-lb. machine at right.

The specifications required that this class of concrete should have a minimum strength of 2,500 lb. per square inch at 28 days, using 6½ gal. of water or less per sack of cement. The results of preliminary tests showed that strength from 10 to 20 per cent higher than required could be obtained using 6½ gal. of water, and the water was not reduced, as this was considered a safe working margin and gave added workability.

The maximum difference in proportions from those recommended was 0.11 of a part in the fine aggregate and 0.24 of a part in the coarse aggregate in the first two contracts in the tabulation, which was largely due to a change in the source of the fine aggregate which caused a reduction in the proportions to secure proper workability. The other proportions used are so close to those recommended that they are practically the same, which is due to the uniformity of the aggregates, the grading of which was kept constant by the use of a two-size fine aggregate and a two-size coarse aggregate which permitted different combinations of these sizes as required to give the same results. These same remarks apply to the differences in the recommended real mix compared with the actual real mix as used in the field.

# Sand-Clogged Outfall Sewer Cleaned and Joints Calked

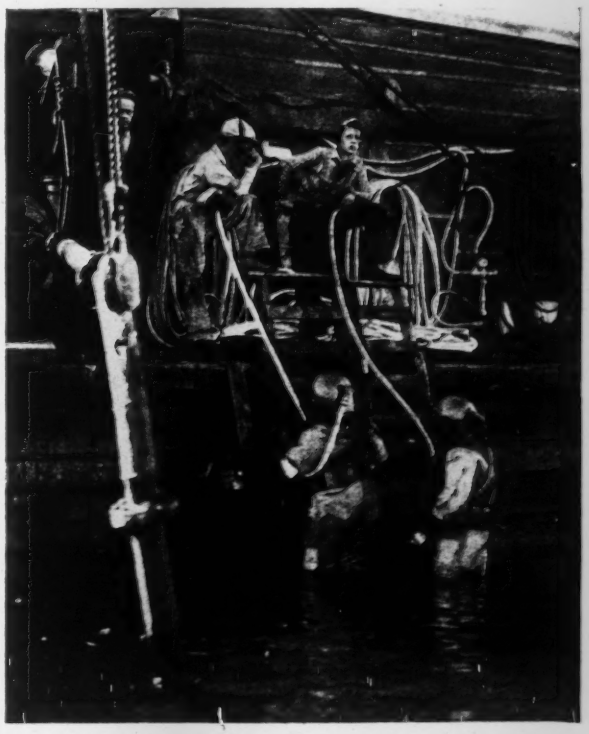
## Silt From Stormwater Blocks Outfall and Settlement Opens Joints—Divers Use Sand Pump and Lead Wool

By L. R. Walker
*Assistant City Engineer, Santa Barbara, Calif.*

LEAKS developing along the outfall sewer at Santa Barbara, Calif., resulting in serious beach pollution, recently necessitated extensive repair work in the ocean section of the line. Investigation showed that settlement had opened the joints between sections of the concrete pipe, and leakage was aggravated because the sewer was partly blocked with sand. Much of this sand deposit is believed to have come from use of the outfall to drain a section of low land during 1927 and 1928, resulting in the discharge of large amounts of sand and silt through the line in the winter season.

The outfall was placed in commission during the spring of 1926 after the work had been interrupted by the earthquake of June, 1925. The 350-ft. section of the line near shore which had been built prior to the earthquake was repaired when work was resumed. The repair work and the construction of the remainder of the line were described in *Engineering News-Record*, Aug. 19, 1926, p. 292.

The line consists of 3,700 ft. of 42-in. concrete pipe in 12-ft. lengths discharging about 3,200 ft. out in the ocean under 45 ft. of water. Approximately 600 ft. of shore section is laid in beach sand; the next section, of



DIVERS WORK FROM BARGE THROUGH MANHOLES
One remains at outfall manhole, the other works inside sewer with suction hose.

280 ft., through the breaker line, is supported on capped piling protected by a cofferdam. The piling support is continued to approximately 700 ft. from the beach line; beyond this point the sewer is laid in a trench dredged on the ocean bottom. Manholes are 300 ft. apart with the exception of the first one offshore, which is 400 ft. from the beach manhole. The joints along the first section of the line were laid with asphaltic compounds. Later an improved joint was devised using a loose rope of oakum coated with asphaltic material. (For details of the joints see article previously referred to.)

First signs of leaks, indicated by the presence of sea gulls, were noticed about a year and a half after completion of the line. Following some unsuccessful attempts to calk these leaking joints with lead wool from the outside, the method was changed, and work started in calking the joints from the inside, beginning at the beach manhole. After proceeding for seven joints from the manhole, the line was found so clogged with sand that the diver was unable to go farther. Equipment was placed on a barge and the joints were calked on the outside to the limit of the $15,000 fund available.

In February, 1929, a bad leak was noted at the manhole 400 ft. from shore. The manhole cover was found to be broken. It was repaired, the line was cleaned for 75 ft. on either side and four joints were calked. The manhole cover then was sealed back and the sewage pumping recommenced but, because of the stopping of the flow beyond this point, the line had clogged completely with sand. The pumping resulted only in opening additional joints inshore. This ended preliminary repair work, as it was not considered economical to do further work until sufficient funds were available to clean the sand from the line and calk all the joints with lead wool from the inside. The estimated cost for this work was $45,000.

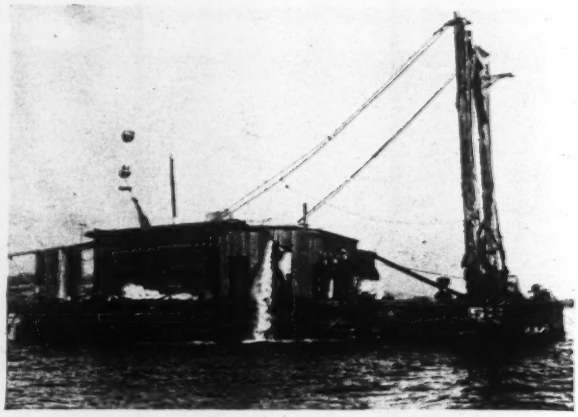
Funds were provided by special election and a lump sum bid was awarded on June 27, 1929, for $39,279. Experience questionnaires were sent to each bidder before the contract was awarded. The contract provided that collars were to be used at joints where the opening was too large to be calked successfully.

*Repair Methods*—The work was done from a barge by divers using a suction hose to remove the sand and pneumatic calking tools to fill the joints with lead wool. The barge was anchored above a manhole and the diver entered the pipe with a 4-in. suction hose which was connected to an 8-in. suction pump on the barge. The diver in the pipe was assisted by another diver stationed at the manhole to help with the suction hose, the air line and necessary tools.

If the sand accumulation was compacted so that it would not yield to suction, it was agitated by the action of a jet from a separate hose line. When the distance from the manhole became too great for the diver to drag the suction hose, it was pulled in by means of a sheave held by a trench jack in the pipe and a line running to a capstan on the barge. This enabled the diver to work the required distance of 150 ft. on either side of the manhole.

As soon as the diver had cleaned the sand 150 ft. each side of the manhole, inspection was made by an experienced diving inspector employed by the city. If sand had been removed satisfactorily from the section, calking was done immediately. All of the old asphaltic filler was removed from the joints and they were calked with lead wool until the joint was filled to the surface. Air hammers were used for calking and lead wool was supplied in rope forms wound on reels for convenience.

The most difficult portion of the work was the 400-ft section between the beach manhole and the first one offshore. The length of the section and the fact that it is on a 6 per cent grade made it difficult for the diver to maintain his position and handle the long length of suction hose. In addition, it was necessary to clear this section at night, as no means of bypassing the sewage from the pump was available and the intervals between



BARGE HEADQUARTERS FOR REPAIR WORK
Discharge is from 8-in. sand pump with intake operated by diver in pipe.

pumpings in the daytime were not sufficient for any work to be done.

As the work proceeded seaward from the first offshore manhole it became easier and progress was faster. A bulkhead was placed in the line beyond this manhole, forcing the sewage to discharge at this point, and work was carried on thereafter in eight-hour shifts. After 1,000 ft. of the line had been repaired the bulkhead was moved out to this new position and the sewage discharged here until the work was completed. The contractor encountered no unusual conditions, and weather was ideal throughout the job. A six months' period was allowed by contract and the work was completed one month ahead of schedule.

The amount of sand in the outfall decreased as the work progressed offshore. Between the beach and first offshore manhole the pipe was two-thirds full; between the second and third manholes a large portion was blocked solid; the remainder of the line was approximately one-half full. The outlet end, which had been laid with the last seven joints curved upward, was found to have settled so that the pipe was half buried in the ocean floor. Following completion of the repair work, a hole was cut in the third pipe joint from the outlet end and a concrete riser extending 5 ft. above the ocean floor was poured. The pipe beyond the riser was bulkheaded. This work was paid for as extra work beyond the contract.

The work required the cleaning of 3,226 ft. of pipe and calking of 260 joints. Two collars were required to be cast around the pipe where the joint had opened too much to be repaired by calking. Working time for the contract work was 118 days and the contractor used 13,575 lb. of lead wool.

The work was done under the supervision of E. B. Brown, city engineer. The contractor was Charles H. Johnston, of Hollywood, Calif., with C. E. Curry superintendent.

# Heavy Rains in New Orleans Tax Drainage Facilities

## Expansion of System by 6,600 Sec.-Ft. of Pumping Capacity Will Provide for Removal of 14 In. of Rainfall in 24 Hours

By George G. Earl

*General Superintendent, Sewerage and Water Board, New Orleans, La.*

RECORDED observations of rainfall intensity in New Orleans, La., are of more than passing interest to the engineers of the Sewerage and Water Board of that city, for, because of topographical conditions and the relative elevations of the city and the neighboring bodies of water, every drop of runoff must be pumped away. During the storm of Sept. 6-7, 1929, according to the figures published by the U. S. Weather Bureau, in about thirteen hours a total of 10.75 in. of rain fell in the business district and 12.96 in. in the uptown area, with a one-hour intensity of 3.18 in. A study of the records of past storms leads to the conclusion that if they were to be repeated today, under changed conditions arising from increased paved area, considerable inconvenience from flooding would result if pumping and drainage facilities were not greatly increased. Accordingly the city's drainage system is now being extended so as to be capable of removing a total of 14 in. of rainfall in 24 hours.

The storm of last September really consisted of two parts, together lasting for thirteen hours, from 5 p.m. on Sept. 6 to 6 a.m. on Sept. 7. During the first period about 3 in. of rain fell between 5 and 7 p.m., with most of the precipitation taking place during the first hour. The second and heavier downpour started at 10 p.m., and between that time and 6 o'clock the next morning a total of 8.84 in. of rain was recorded. The intensity of this second downpour can be judged from the figures given in the U. S. Monthly Meteorological Summary for September, which records intensities of 3.18 in. for one hour, 5.71 in. for two hours, 8.29 in. for five hours and 8.84 for eight hours.

The uptown area of the city, comprising some 11,000 acres, is served by a pumping station having a total nominal removal capacity of about 3,500 sec.-ft. This is equal to the removal of 0.3 in. per hour of rainfall. The removal capacity for the city as a whole is 7 in. in 24 hours. With a total rainfall of 12.96 in., practically all of which fell within a thirteen-hour period, it is evident that for a long time the rain was falling much faster than the pumps could remove it, and storage of water on the city streets for a short period resulted. However, the maximum depth of flooding was not more than 3.7 ft., as the lowest established curb grades in the uptown low area are at El. 19 and the highest water reported in this area was at El. 22.7. A depth of 7 ft. was erroneously reported in *Engineering News-Record*, Sept. 12, 1929, p. 432. All the water from this very intense rain was removed from the central section almost immediately, while by 10 a.m. it was removed from the major part of the city. It was not until midnight that the lowest sections of the low areas were entirely free of water.

In 1923 two heavy rains, with an intensity of about 5 in. in five hours, resulted in the overcharging of all canals, drains and pumping stations and a little flooding of the lower areas. Attention was drawn to the fact that four or five much heavier rains had been recorded in the past, but that present conditions of runoff were such that far greater inconvenience would develop were they to be repeated now.

Two storms in 1926, one of 7.45 in. in five hours and another of 8.1 in. in seven hours, were not sufficient to arouse public interest to the point of action, but in 1927 the most intense rainfall ever recorded in New Orleans, 14 in. in nineteen hours, was sufficient stimulus to bring about the present construction program, for which the first money became available to the city in November, 1928.

Work in progress or under contract at present includes the expansion of power facilities, additions to pumping equipment and enlargement of drainage canals. Additional boilers and a 15,000-kw. turbo-generator will more than double the power available for drainage pumping. Four 14-ft. screw pumps at station 6 and three such pumps at station 1, having a capacity of 1,000 sec.-ft. each, will greatly increase the discharging capacity for the uptown area. Extensions and enlargements of the canals receiving the discharge from stations 6 and 1 will increase the rate of delivery at these points. Enlargements are planned at three other pumping stations also.

When improvements at station 6 are completed, the pumping equipment there will include four 300-sec.-ft. centrifugal pumps, two 700-sec.-ft. screw pumps and four 1,000-sec.-ft. screw pumps, or an aggregate capacity of 6,600 sec.-ft. The station will be 50 ft. wide and 292 ft. long, and a screen 250 ft. long will be necessary to protect the pumps. So extended, the capacity of this station will be 0.6 sec.-ft. per acre of the area draining to it, equal to the removal of 0.6 in. of rainfall per hour from that area.

When these extensions are completed, the capacity of all the pumping stations in the city will be such as to be capable of removing 14 in. of rainfall in 24 hours. Although there are, of course, quite a few storms on record of much greater intensity than this figure, their frequency of occurrence, or rather infrequency, is such that the expense of installing equipment of greater capacity than this would not be justified at the present time.

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## Difficult Foundation Problems Solved for London Office Building

In placing foundation piers for the new building erected as headquarters for the London Underground Railways at Westminster, it was necessary to use cross-girders spanning a subway which traverses a portion of the site. The cross-girders, 54 ft. long with a maximum weight of 82 tons, rested on groups of piles at each side of the railroad. The 39,000-ton weight of the building is carried on 700 vibrated reinforced-concrete, cast-in-place piles, 17 in. in diameter. An existing egg-shaped sewer 7 ft. below street level, was isolated with sheet piling before driving of the bearing piles was started. Complaints arising from the noise of the piling hammer were minimized by fitting a specially designed silencer on the winch exhaust and by using a dolly of rock elm with a steel plate cap to deaden the blow of the pile hammer. These dollies were short lived and somewhat costly, 111 of them being used on the job at a cost of 3c. per foot of piling driven.

# Letters to the Editor

## *A Forum for Expression of Views by Engineers and Contractors*

### *Solving the Three-Point Problem*

Sir—After reading "Solving the Three-Point Problem," by F. S. Foote on p. 534 of *Engineering News-Record* for March 27, 1930, it occurred to me that there ought to be a direct solution for the part of the problem which was solved by trial, and the formula herewith is the result. It appears that this solution involves nearly as much work as the author's trial method.

Given $\frac{\sin x}{\sin y} = a$ and $x + y = b$, to find the two angles $x$ and $y$.

From trigonometry we have

$$\cos b = \cos (x + y) = \cos x \cos y - \sin x \sin y.$$

But $\sin x = a \sin y$. $\cos x = \sqrt{1 - \sin^2 x} = \sqrt{1 - a^2 \sin^2 y}$ and $\cos y = \sqrt{1 - \sin^2 y}$.

Making these substitutions,

$$\cos b = \sqrt{1 - a^2 \sin^2 y}\ \sqrt{1 - \sin^2 y} - a \sin^2 y$$
$$= \sqrt{1 - \sin^2 y - a^2 \sin^2 y + a^2 \sin^4 y} - a \sin^2 y$$

Transposing,

$$\cos b + a \sin^2 y = \sqrt{1 - \sin^2 y - a^2 \sin^2 y + a^2 \sin^4 y}$$

Squaring,

$$\cos^2 b + 2a \cos b \sin^2 y + a^2 \sin^4 y = 1 - \sin^2 y - a^2 \sin^2 y + a^2 \sin^4 y$$
$$\sin^2 y + a^2 \sin^2 y + 2a \cos b \sin^2 y = 1 - \cos^2 b = \sin^2 b$$

From which

$$\sin y = \sqrt{\frac{\sin^2 b}{a^2 + 2a \cos b + 1}} \quad \text{and} \quad x = b - y$$

Example: Let $a = 0.66313$ and $b = 51° 34' 20''$.

$$\text{Then } \sin y = \sqrt{\frac{\sin^2 51° 34' 20''}{0.66313^2 + 2x\ 0.66313 \cos 51° 34' 20'' + 1}}$$
$$= \sqrt{\frac{0.61370}{0.43974 + 0.82430 + 1}} =$$
$$\sqrt{\frac{0.61370}{2.26404}} = \sin 31° 22' 30''$$

| | |
|---|---|
| Log sin 51°34′ 20″ | = 9.89398 |
| | 2 |
| Log sin² 51° 34′ 20 | = 9.78796 |
| Sin² 50° 34′ 20″ | = 0.61370 |
| Log 0.66313 | = 9.82160 |
| | 2 |
| Log 0.66313² | = 9.64320 |
| 0.66313² | = 0.43974 |
| Log 2 | = 0.30103 |
| Log 0.66313 | = 9.82160 |
| Log cos 51° 34′ 20″ | = 9.79346 |
| Log 2a cos b | = 9.91609 |
| 2a cos b | = 0.82430 |
| Log 0.61370 | = 9.78796 |
| Log 2.26404 | = 0.35489 |
| | 2)9.43307 |
| Log sin y | = 9.71653 |
| ∴ y | = 31° 22′ 30″ |
| But b | = 51° 34′ 20″ |
| ∴ x | = 20° 11′ 50″ |
| Proof: | |
| Log sin 20° 11′ 50″ | = 9.53813 |
| Log sin 31° 22′ 50″ | = 9.71653 |
| Log $\frac{\sin x}{\sin y}$ | = 9.82160 |

This is the same as log $a$ above, thus proving the correctness of the solution.

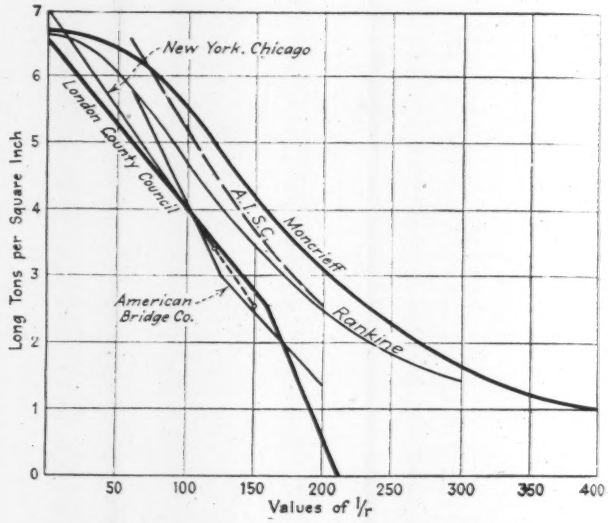
Kansas City, Mo., April 4, 1930.

D. M. Dodd, Structural Engineer.

### *Structural Steel Regulations Here and Abroad*

Sir—I note on p. 664 of your April 17 issue a letter from "Three Practical Designers," dated London, March 26, in which is registered a protest against your editorial "Structural Awakening Abroad," which appeared in your Feb. 20 issue. In this connection, with point 2 in the letter under review, it may be well to point out that on March 24 last Mayor Walker signed a bill amending the building code of the city of New York, this bill permitting the use of an 18,000-lb. basic unit stress in structural steel, which is practically identical with the allowable stress in steel used in London for some years past.

The American Institute of Steel Construction is co-operating with the British Steelwork Association in assisting it to modernize the regulations of the London County Council so as to stimulate building enterprise in Great Britain. At present the London County Council regulations prohibit the use of hollow tile or brick in any wall construction, which, of course, militates against efficient design of steel-framed buildings. We have furnished the British Steelwork Association with a résumé of the wall-construction requirements of the New York code, and it is hoped that the London regulations will be modernized so as to remove the present handicap to steel construction in that city.




COMPARATIVE COLUMN-FORMULA CURVES
Moncrieff formula generally used in England; London County Council formula governs in London area only. A.I.S.C. formula largely used in the United States and Canada.

Regarding the London County Council column formula and the comparative column-formula curves accompanying the published letter, it is interesting to note a plot of the A.I.S.C. column formula superimposed upon the comparative curves illustrated, especially in view of the fact that the institute's formula has a wider use throughout the United States and Canada than either the old New York and Chicago or the American Bridge Co.'s formulas. A tabulation of the A.I.S.C. column formula as applicable to values of $l/r$ from 60 to 200 inclusive is as follows:

| $l/r$ | Lb. Per Sq.In. | Long Tons Per Sq.In. |
|---|---|---|
| 60 | 15,000 | 6.70 |
| 100 | 11,571 | 5.17 |
| 150 | 8,000 | 3.57 |
| 200 | 5,590 | 2.50 |

The purpose of this letter is in line with the suggestion contained in the letter of "Three Practical Designers"—that is, that "much can be gained by exchange of views."

New York City, April 25, 1930.

F. H. Frankland, Director of Engineering Service, American Institute of Steel Construction, Inc.

# News of the Week

## Los Angeles Votes $38,800,000 Water Bonds

By an overwhelming majority the voters of Los Angeles, Calif., at a special election held May 20 authorized the issuance of water bonds amounting to $38,800,000. Of this amount approximately 50 per cent will be used for the purchase of water rights and riparian land, and the rest will be spent for construction purposes, including additional terminal storage, and improvement of the present distribution system.

Under the present plans the proceeds of the bond issue will be allocated as follows: for the purchase of Mono Basin properties and water rights, $7,000,000; for the purchase of privately owned land in Long Valley and Owens Valley, $6,660,000; for the purchase of the towns of Bishop, Laws, Big Pine, Independence and Lone Pine, $5,790,000; new construction—conduit from Leevining Creek to Silver Lake, $1,450,000; Silver Lake dam, $550,000; 11-mile tunnel from Silver Lake to headwaters of Owens River, $5,500,000; Long Valley dam, $750,000; improvements—increasing capacity of aqueduct from 400 to 440 sec.-ft. at certain points, $600,000; increasing storage capacity, $7,500,000; new pipe line from Chatsworth to Hollywood reservoir, $1,445,000; additions to distributing system, $1,555,000.

## Washington Communities to Take Over Water Systems

The water system of the Oregon-Washington Water Service Co. was taken over by Hoquiam, Wash., on May 16 on the payment in court of $510,000 awarded in a condemnation suit.

The city of Salem, Wash., voted on May 16 in favor of a charter amendment authorizing a bond issue of $1,200,000 to acquire municipal ownership of the local water plant from the Oregon-Washington Water Service Co.

## Gustav Lindenthal Honored on Eightieth Birthday

Gustav Lindenthal, bridge engineer and honorary member of the American Society of Civil Engineers, was the guest of sixteen fellow engineers at a luncheon held at the Engineers' Club, New York, on May 21, to celebrate his 80th birthday. It was an old-fashioned surprise party, to which the unsuspecting guest was lured by strategem and of which the crowning feature was a specially baked birthday cake adorned with eight candles to number the decades of his years.

Charles Evan Fowler presided as toastmaster, and brief talks were made by Francis Lee Stuart, Robert Ridgway, O. H. Ammann and Willard Chevalier, all offering their tribute of respect to the professional and personal qualifications that have won for Mr. Lindenthal his unique position in American engineering.

Others present were Edward A. Byrne, George Gibbs, W. H. Yates, T. Kennard Thomson, Otis E. Hovey, George H. Pegram, George T. Seabury, F. D. Trask, Lawrence A. Tanzer, R. H. Trott and Joseph D. Holmes.

## Steel Cores for Four-Story Concrete Building Collapse During Erection

### Two Workmen Killed When Derrick Being Dismantled on New Gottfried Bakery Building in New York Falls, Dragging All Columns on a 100x225-Ft. Site to the Ground

THE dropping or failure of a derrick boom while it was being removed from among the standing structural steel cores for the four-story reinforced-concrete building being erected for the Gottfried Bakery Co. in New York City started a collapse of steelwork that did not end until the entire site, 100x225 ft., had been leveled. Two men were killed and ten injured. The fact that the collapse was relatively gradual permitted the remainder of the 60 workmen in the building to escape. The accident occurred on Thursday afternoon, May 22, after the steel erectors had completed their work of setting the 42 column cores and were removing their equipment from the site. Carpenters had just begun the erection of formwork for the first-floor concrete.

The building, which was of the familiar composite-column type, consisting of reinforced-concrete columns with structural steel cores and reinforced-concrete floors and beams, is located on the corner of the block, having a frontage of 100 ft. on Eleventh Ave. and 225 ft. along 51st St. There was a basement under only a small area at the rear of the lot. The building was being erected in the usual manner of standing the structural steel cores in place and bracing them with temporary ties which served to hold them plumb until the concrete floors were poured. The cores, which were 65 ft. long, were completely shop-fabricated. In erecting them, the two derricks remained on the ground. The bracing system consisted of 6-in. I-beams and channels, bracing each column four ways at a point 6½ ft. above the third-floor level. Diagonal guy cables

*Wide World Photo*

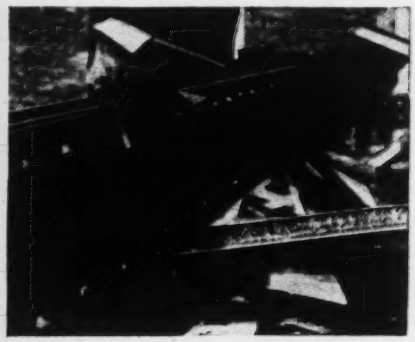
WRECKAGE OF STEEL COLUMN CORES FOR REINFORCED CONCRETE BUILDING IN NEW YORK CITY

Only the three columns shown standing at the far corner of the site remained after a derrick boom resting on the ground and serving as a gin-pole toppled against the steelwork. The lattice members shown in the foreground are sections of the derrick mast which had been dismantled following completion of the erection of the steel cores for the four-story building.

were also used on some of the cores in accordance with usual practice on this type of steel erection.

At the time of the collapse the last remaining derrick was located about two-thirds of the distance from the front end of the building, from which position it had completed erection of the steel cores. The mast had been dismantled after being lowered to the ground by means of the boom, used as a gin-pole. According to reports, the boom was being lowered when it toppled or collapsed against some of the steelwork, whether a column or one of the temporary braces has not been established. The column nearest the base of the derrick fell outward in the same direction taken by the derrick boom. This column is leaning at a 45-deg. angle against an adjacent building. Another column near by fell outward in the opposite direction across 51st St. Most of the other columns, and particularly those on the front part of the lot and farthest removed from the derrick, fell with their tops toward the derrick, indicating the possibility that, with the collapse of several columns near the derrick, the bracing acted as a guying system to pull the remainder of the steelwork down.

In only three instances was the anchorage of the columns or foundations sufficient to resist the collapse. The three columns which remained standing, although badly bent, may be seen in one of the accompanying illustrations. Each column rested on an individual foundation consisting of a concrete block about 3 ft. deep and 4 ft. square, resting on rock but not anchored thereto. Steel base slabs were cast in the concrete and anchored by means of two 1-in. diameter bolts 2 ft. long. Two connection angles, 6x4x$\frac{3}{8}$ in., were welded to these base slabs in the shop, a welded bead being placed along all four sides of the horizontal leg. The column cores were set between these two angles and connected by means of two bolts to each angle. An examination of the wreckage shows that on some columns the bolts sheared off, on others the angles were torn from the base plates, failing in the welds, while on still others both the bolts and the welds held, resulting in a complete uprooting of the foundation blocks.



TYPE OF HORIZONTAL BRACING CONNECTION USED, GOTTFRIED BUILDING

Shop-riveted strap iron provided two bolt holes for each 6-in. brace. The bracing system was located 6½-ft. above the third-floor level on the 65-ft. columns.

The structural steel cores were being erected by the Harris Structural Steel Co., Inc., for the White Construction Co., Inc., general contractor. C. B. Comstock is the architect.

## Harbor at Richmond, Calif., to Be Developed

An important step in the development of the harbor of Richmond, Calif., is dredging and filling in the Ellis Slough, which will extend the inner harbor and make it possible for deep-water ships to sail up as far as Cutting Boulevard in Richmond. The development of the project has been authorized and contracts for construction have been let. The new channel is to be 300 ft. wide and about 4,000 ft. long, and will have a turning basin at Cutting Boulevard 600 ft. wide and 1,000 ft. long. The channel will connect directly with the present inner harbor.

When completed, the project will open up an area of about 400 acres of industrial land now submerged and will greatly increase the berthing space on the Richmond waterfront.

## Mellon Institute Announces Plans for New Building

Edward R. Weidlein, director, Mellon Institute of Industrial Research, Pittsburgh, Pa., announces that the institution will increase its facilities by a building project that will enable the material expansion of all its research activities. Detailed plans are now being prepared and construction will begin early next fall. The Mellon-Stuart Co., Pittsburgh, is the general contractor.

The building, which is to occupy the site of the institute's Building No. 2, will provide space for housing many more industrial fellowships than the 63 that now tax the institute's facilities to the utmost. The other departments of the institute will be increased in proportion.

## Department of City Planning Urged for New York

Mayor Walker, of New York City, has introduced into the Board of Estimate and Apportionment a bill creating a department of city planning, under the control of a single commissioner, to advise on matters of building and zoning and all future developments in the metropolis.

Unsuccessful attemps have been made at the last two sessions of the state legislature to pass a bill creating such a department with arbitrary powers. Under the provisions of the present bill, the department would have merely advisory powers, but its advice would have to be sought before changes could be made in a model plan, which the department would set up.

## J. Franklin Bell Ousted as City Manager of Covington

At a secret meeting on May 18, [illegible] city commissioners of Covington, K[illegible] by a vote of four to one, asked for [illegible] resignation of J. Franklin Bell, who [illegible] been city manager for the past f[illegible] months. Colonel Bell, who resig[illegible] from the U. S. Army to accept the p[illegible] immediately tendered his resignat[illegible] and it was accepted. Colonel Bell [illegible] no contract with the city and his sal[illegible] of $12,000 was paid by the contribut[illegible] of the salary of $3,000 of four comm[illegible] sioners. No explanation was given [illegible] the commissioners for their action e[illegible] cept that "the methods of operating t[illegible] various city departments under Colonel Bell were not in accord with the wishes of the commissioners."

The resignation did not meet with the approbation of all the citizens of Covington and several mass meetings have been held protesting against the action of the commissioners.

## Excess Condemnation in Cincinnati Declared Invalid

The U. S. Supreme Court has decided that condemnation of property in excess of that acquired directly by the city of Cincinnati for street widening, without proof on the part of the city authorities at the time of such condemnation that the excess property was to be used for a public purpose, is invalid, not being in conformity with the constitution and statutes of the state. The court declined to pass upon the question of whether the excess condemnation provision of the Ohio constitution was valid or not, but declared that the statutes of Ohio require the city council to provide specifically the purpose for which the excess property is contemplated at the time of providing for its condemnation.

## Suits for Waterborne Typhoid Compromised by Company

Typhoid claims against the Texas-Louisiana Power & Light Co. resulting from a typhoid epidemic at Richfield Springs, Tex., in the autumn of 1929 have been compromised for $15,000, following court action. Twenty-eight cases of fever "variously diagnosed" were reported to the representative of the Texas State Board of Health. Only one death occurred. The wife and five children of the deceased will be paid $5,000 and the remaining $10,000 is to be distributed for the benefit of the survivors or their relatives. The complainants alleged that the local water supply was contaminated through the carelessness of the company. E. G. Eggert, of the engineering department of the state board of health, informs *Engineering News-Record* that the springs forming the source of water supply were "possibly infected by septic tank drainage or by surface drainage from open privies." The estimated population of Richfield Springs is 800.

## Phoenix, Ariz., to Vote on Water and Sewer Bond Issue

The city commissioners of Phoenix, Ariz., have formally set June 25 as the date for a special election on a $3,422,000 bond issue for water and sewer improvements. The bond issue, if voted, is to be divided as follows: water-system improvements, $2,364,000; sewer system, $817,000; payment of notes covering loans for laying 5 miles of concrete pipe lines in 1927, $200,000; payment of a loan from the Salt River Valley Water Users' Association, $41,000.

## $15,000,000 Freight Depot Planned for New York

The Port of New York Authority has announced plans to spend $15,000,000 to obtain property bounded by Eighth and Ninth Aves. and West Fifteenth and Sixteenth Sts., in New York City, and to erect a fourteen-story union inland freight terminal on the site. One-half the property has already been obtained for about $1,500,000. The Port Authority announces also that the railroads entering New York have agreed to sign contracts to lease the terminal.

It is pointed out that the union terminal will enable merchants and manufacturers, who now must collect their incoming package freight from half a dozen stations and carry it in small lots back and forth, to collect it at one place.

In connection with carrying out present and future construction projects, the Port Authority has engaged James C. Forgie and Robert Ridgway as consulting engineers and has continued the consulting services of Prof. William H. Burr and Daniel Moran. Mr. Forgie was one of the engineers who built the Pennsylvania Railroad tunnels between Manhattan and New Jersey. Mr. Ridgway is chief engineer of the New York Board of Transportation. Professor Burr and Mr. Moran have served as consultants on the Hudson River bridge.

## I.C.C. to Investigate Thoroughly Motor Bus Connections

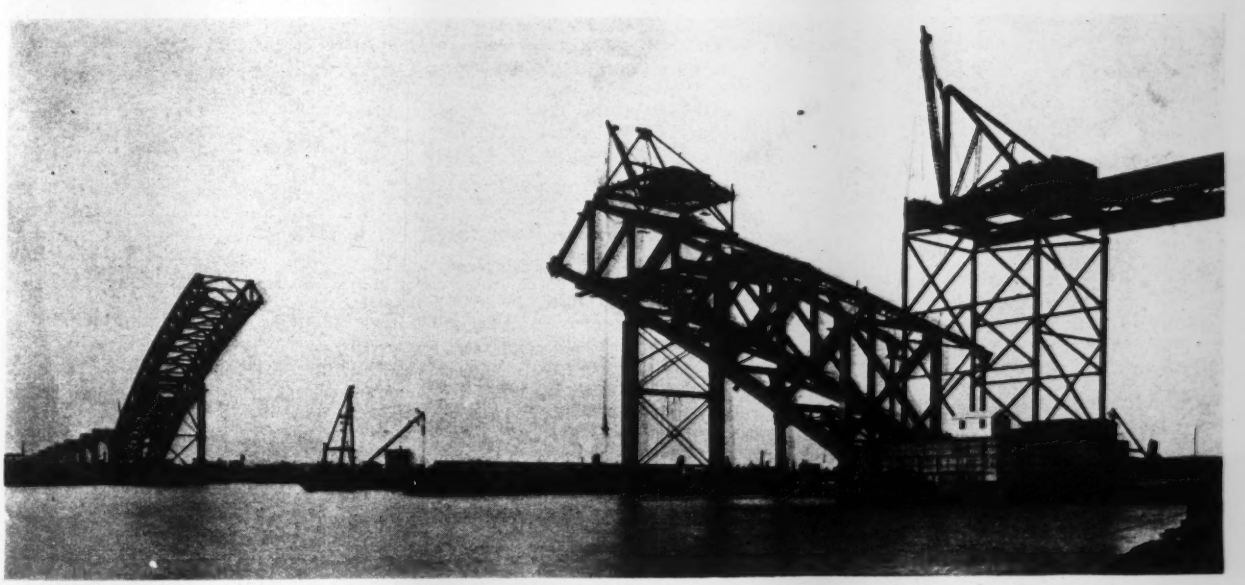
With a view of acquainting the Interstate Commerce Commission with the entire motor transportation situation in order that the commission may make recommendations to Congress as to additional legislation needed relating to this section of the transportation field, the commission has announced an exhaustive investigation into the general matter of co-ordination of motor transportation of passengers and property on the public highways by or in competition with the railroads.

The investigation will include such situation as that involved in the Baltimore & Ohio motor coach service between Jersey City and numerous destination points throughout the New York metropolitan district, and the Pennsylvania Railroad's proposal to meet the competition resulting therefrom by means of a similar bus service.

## State Water Rights Clarified by Connecticut River Report

The report of Special Master Charles W. Bunn, the filing of which was briefly reported last week, p. 872, recommends that the request of the State of Connecticut for an injunction to prevent the Commonwealth of Massachusetts from diverting for the Boston water supply a part of the waters of the Ware and Swift rivers, tributaries of the Connecticut River, be denied. The master did not uphold the contention of Connecticut that, since both states have adopted the common law of riparian rights, the Supreme Court has nothing to do but to apply the strict rule of the common law in making its decision. He also found without merit the contention of Connecticut that any invasion of the rights or privileges of a state calls for an injunction regardless of damage. The principle to be applied, the master holds, is equality of right, and the particular inquiry is whether the proposed diversion will seriously and substantially cripple the flow of the Connecticut River.

Connecticut contended that the proposed diversion would result in serious damage to the state and its people by injuring the navigability of the stream, diminishing the inundation of certain bottom lands along the river, diminishing the power available at a proposed development at King's Island, a few miles below the state line, reducing the capacity of the river to discharge and destroy sewage, and injuring the fish-



**RAPID PROGRESS BEING MADE ON KILL VAN KULL ARCH**

**The south arm, consisting of fourteen panels, of the 1,675-ft. Kill van Kull arch connecting Staten Island and New Jersey at New York City is completed, and on May 16, when the above photograph was taken, six panels in the north arm were in place. Closure will be made at panel point 14 on the south arm, six panels south of the center at panel point 20, because of War Department orders that no falsework obstructions be placed in the ship channel. The last falsework bent under the north arm will be placed at panel point 16. The north approach steelwork is in place, but that in the south approach will not be erected until the arch is completed, inasmuch as a large portion of it is being used as arch falsework. In the first progress report which was recently issued, O. H. Ammann, chief engineer of bridges of the Port of New York Authority, stated that it is confidently expected that the bridge will be completed and opened to traffic some time early in the spring of 1932.**

ing industry. Such injuries, Mr. Bunn declared, would be inconsequential, with the possible exception of the proposed power project at King's Island, where the master found that if the diversion did hamper the construction of the plant to its possible capacity the resultant damage would be about $80,000. In compensation for this, it is suggested that the court's decree require Massachusetts to pay to the power company or its assigns $80,000 if and when the power is developed to the extent stated.

Connecticut's contention that the Boston district could well be supplied with water from the eastern part of the state was found to be impracticable, as such water is held to be, for the most part, polluted and would require substantial and extensive treatment. The preference for a supply of pure water is held to be justifiable.

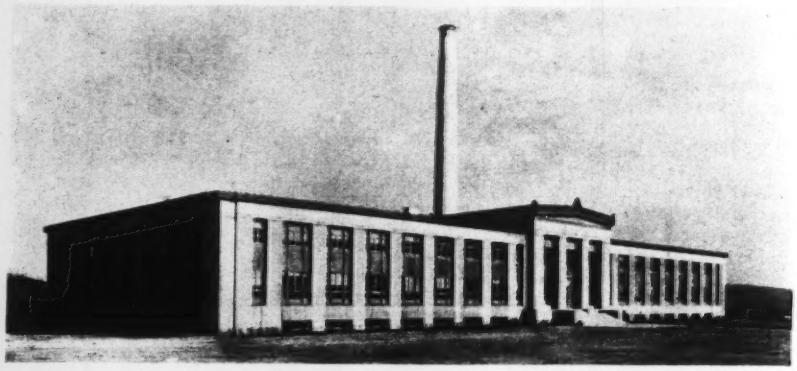
## New York City Awards Contract for East River Subway Tunnels

Contract for the construction of two single-track subway tunnels, each 5,474 ft. long, under the East River from Madison and Rutgers Sts., Manhattan, to Jay and Nassau Sts., Brooklyn, was awarded by the New York Board of Transportation on May 21 to the Mason & Hanger Co., New York, for $11,674,060. This is part of the Houston-Essex St. line of the city's new independent subway system and is known as Section 4, Route 103. The entire length of the tunnels will be shield-driven and lined with cast iron. Driving will be done from two shafts, 3,427 ft. apart, located on each bank of the river. There will be one station on the line, at Jay and York Sts. in Brooklyn. The Brooklyn land tunnels will pass under the east approach of the Manhattan bridge.

The Mason & Hanger Co. is now engaged in completing the Fulton St. subway tunnels under East River, 9,020 ft. long. Contract for this work, totaling $22,300,000, was the largest single contract ever let for subway work in New York, although exceeded by the $42,692,567 water-tunnel contract of Patrick McGovern, Inc.

## Sanitary Engineer Wanted by Westchester County, N. Y.

The New York State Civil Service Commission will conduct an unwritten examination some time subsequent to June 14, for which applications should be filed by that date, for sanitary engineer, department of health, Westchester County. The salary is $4,500 to $5,000 a year. The duties include acting as personal representative of the county health officer wherever assigned within the county, especially to investigate and advise on operation of water supplies, sewage-disposal works and swimming pools, supervise milk sanitation, examine alleged nuisances and deal with general problems of public health sanitation. The examination is open to residents of any county of New York State.



**RESEARCH LABORATORY OF ALUMINUM COMPANY OF AMERICA**

**This large laboratory, at New Kensington, Pa., was formally opened last week. It is 275 ft. long with a 108-ft. wing at each end, contains 56,000 sq.ft. of floor space and accommodates a research staff of 150. Henry Hornbostel, of Pittsburgh, was the architect. The interior is divided into separate units for the chemical, metallurgical, physical, paint, development and other divisions of the laboratory. Aluminum was used extensively in construction and equipment, in both cast and wrought form: for copings, cornices, spandrels, window and door frames, on the exterior; ornamental doors, chairs, tables, radiator covers, stair balustrades, distilled water system, and all piping, in the interior. Enlargement of the building to about twice its present size by completing the U to form a hollow square is provided for in the layout. The site is a 14-acre tract on a hill overlooking the town of New Kensington, on the Allegheny River. One of the company's principal fabricating plants is located in the lower part of the town, and here the research department was housed until now. Small research organizations are maintained at five other plants.**

## $3,000,000 Copper Refinery for Montreal

An announcement concerning the erection of an electrolytic copper refinery in Montreal East by Canadian Copper Refiners, Ltd., states that the plant, including land, will cost approximately $3,000,000. The plant is being constructed primarily to refine the copper produced at the smelter owned and operated by Noranda Mines, Ltd., but will also operate as a customs refinery.

## Detroit City Engineer Reinstated by Civil Service Commission

Recently dismissed from his position as city engineer of Detroit, Perry A. Fellows was ordered reinstated by the Civil Service Commission of that city on May 14, on the ground that his discharge by John Gillespie, commissioner of public works, had been for reasons other than the good of the service. Mr. Fellows, charged with inefficiency and insubordination, was discharged following the failure of a portion of the Southfield Road sewer.

The 6-mile-long Southfield Road sewer, of plain concrete, was built two years ago for the purpose of draining a large part of the western section of the city. The design and construction were under the supervision of the city engineer. As stated in *Engineering News-Record* of April 17, p. 665, Mr. Fellows was dismissed after a portion of the sewer running through quicksand had failed. An appeal to the Civil Service Commission to order his reinstatement because his dismissal had been for political reasons resulted in a three-day hearing of the case.

Testifying in Mr. Fellows' behalf were H. P. Eddy, consulting engineer, Boston; Prof. Ralph B. Wiley, of Purdue University, and John W. Reid, former commissioner of public works of Detroit and predecessor to John Gillespie. These engineers expressed their confidence in the ability of the city engineer and testified that the structure in question had been designed in accordance with accepted engineering principles; they gave as their opinion that failure due to faulty design would have taken place immediately following the placing of the backfill. They further stated that although the quicksand underlying the sewer would be a satisfactory foundation as long as it remained undisturbed, any pumping of groundwater in the vicinity would be likely to destroy its integrity as a supporting material and involve dangerous consequences. Some pumping was done immediately before the collapse.

The act of insubordination, as charged by the commissioner, consisted of Mr. Fellows' public statement approving a proposal by one of the councilmen that the sewer failure should be investigated by a committee of impartial and competent engineers, after the commissioner had declared that such investigation would be carried out by his department.

An investigation committee consisting of C. G. Wrentmore, Detroit, chairman; George H. Ruhling, Detroit, and A. H. Smith, Toledo, has not yet made its report.

# WASHINGTON NOTES

By Paul Wooton
*Washington Correspondent*

## Potomac Park Bill Signed by President—Rivers and Harbors Bill Is Criticised in Senate

CLEVER maneuvering on the part of Senator Glass, of Virginia, has saved the bridge over the Potomac near Great Falls for the people of northern Virginia and southern Maryland. During the controversy in the House over the Cramton bill, setting aside for park purposes the gorge of the Potomac from Great Falls to Washington, an existing law authorizing a toll bridge below the falls was repealed. Plans for the bridge had reached a point where actual construction was about to begin. The action of the House was a great disappointment to the people of the locality. Senator Glass succeeded in amending the bill in the Senate so as to allow the toll bridge to go forward with the provision that the structure may be recaptured at any time by the government on the payment of a sum equivalent to the actual cost plus 10 per cent. The act has just been signed by the President with that provision in it. As a result the Great Falls Bridge Co. is expediting its arrangements and promises the completed structure within fifteen months. The bridge will cost $1,500,000.

### Action on Boulder Dam Expected This Session

Whether Boulder dam construction will start this season rests with the House committee on appropriations, hearings having ended on May 23. From all that can be gathered concerning what took place in the closed sessions it is believed that the Interior Department has made its case against Arizona's objections and that the committee will report favorably on the requested sum of $10,660,000 to start the project. This would go in the second deficiency bill, which, according to plans, is to be reported early in June. Asked how long after appropriation it would take to get the project in motion, Secretary Wilbur answered, "Five minutes."

For an appropriation to be made under the Boulder dam act, four elements are required: six-state ratification; approval of the compact by presidential proclamation; passage by California of an act agreeing to accept 4,400,000 acre-ft. per annum as a maximum primary water apportionment; and power contracts providing revenue to amortize the project. All these points were taken up in detail in the hearings, the Interior Department's stand being that all are satisfied to the letter. Objections were directed principally at alleged flaws in the power contracts which the department has procured on the grounds that Los Angeles is without authority to contract for electrical energy from Boulder dam and that Secretary Wilbur cannot legally agree, on the basis of the Chicago diversion decision, to send water to the Metropolitan Water District outside the Colorado River basin. It is hardly expected that the committee will seek to pass upon the points of law on which these contentions are based but that the way will be paved toward court action by going through the preliminary step of approving the funds.

Undoubtedly the opponents of the project in Congress will fight the bill, but the general opinion still is that it has a good chance for passage this session. Senator King, of Utah, has been seeking further efforts to reach an agreement with the recalcitrant states, but after so many repeated failures the prospects seem remote. Arizona is still expected to file an injunction suit to halt construction till her legal rights are determined in the courts.

### Senate Increases Appropriation for Rivers and Harbors

After working out a compromise on several of the major projects, the Senate commerce committee has reported out the rivers and harbors bill with an increase of $10,000,000 over the $110,000,000 appropriation recommended by the House.

Difficulty was encountered by the committee in agreeing upon the sections of the measure dealing with the Illinois waterway and the Erie Canal. Opposition to the nationalization of both of these waterways was made by the Lake states. To meet these objections, language was adopted authorizing the Secretary of War to control the diversion of water from Lake Michigan to the Mississippi River so that the interests of navigation on the Great Lakes will be protected.

In regard to the Erie and Oswego canals, the bill was amended by the inclusion of a section declaring that it is the policy of the government to use these canals only for barges and not to convert them into deeper waterways for ships. It also was agreed to limit their annual maintenance cost to $2,500,000.

The criticism has been made that the Senate committee has increased excessively the amount of authorization contained in the bill. Senator Vandenberg contends that the measure now authorizes a total of more than $300,000,000. This statement was made in connection with the committee's action in increasing the amount authorized on the upper Mississippi and on the Tennessee river. The section dealing with the upper Mississippi between Illinois and Minneapolis was amended so as to authorize a 9-ft. project. Senator Vanderberg's objection is that this would involve an ultimate expenditure of $98,000,000, even though the immediate authorization is for only $7,500,000.

Similarly a 9-ft. project was authorized on the Tennessee, involving an estimated expenditure of $75,000,000, of which only $5,000,000 is immediately available. It is contended that the only efficient and scientific procedure to follow in rivers and harbors work is to adopt a definite and related series of projects so that succeeding appropriations can be utilized according to a particular plan. As an indication of the wisdom in thus looking ahead attention is called to the improvement of the Ohio. The 9-ft. project on this river, adopted as long ago as 1910, involved a total authorization of $63,000,000. The money was spent over so long a period, however, that only recently was the final work completed.

### Moffat Tunnel Control May Go to the Rio Grande Road

Acquisition by the Denver & Rio Grande Western Railroad of control of the Denver & Salt Lake Railway in accordance with the terms suggested by the former is recommended in a proposed report by Examiner M. S. Jameson to the Interstate Commerce Commission. The D.&R.G.W., in which the Van Sweringen brothers have acquired a half interest by purchasing control of the Missouri Pacific, has purchased 21,334 shares of Salt Lake at $155 and has agreed to purchase an additional block of 7,635 shares at the same price, subject to the commission's approval. These purchases will give the D.&R.G.W. 58 per cent control of the Moffat road. Examiner Jameson finds that the price is reasonable and recommends that a condition should be attached to the commission's order directing the Rio Grande to purchase at the same figure any stock or voting trust certificates which may be offered to it within six months. This condition is acceptable to the Rio Grande.

Acquisition of the Denver & Salt Lake will give to the Rio Grande the use of the Moffat tunnel, which was leased to the Salt Lake for 50 years in January, 1926. The lease of the tunnel is in litigation. It was sustained in October, 1929, by the U. S. District Court for Colorado, but certain of its provisions were nullified. It is understood that an appeal will be heard by the U. S. Circuit Court of Appeals for the Tenth Circuit in June and a decision is expected next fall.

### *The Business Outlook*

**The general level of business activity shows further improvement and has approached the normal level for the season and year more closely than at any time since the brief and erratic spurt of January. *The Business Week's* preliminary index has risen to nearly 98 per cent of normal, as compared with the final revised figure of 96.6 for the preceding week. The nearness of this week's figure to normal may be temporary, but increases in three successive weeks indicate that the general trend is still upward.**

***—The Business Week, May 28.***

## Flaws in Dams to Be Studied by Bureau of Reclamation

An investigation of cracks in dams through a series of field studies is to be undertaken at an early date by the U. S. Bureau of Reclamation. These studies, which will be made by Prof. H. N. Westergaard, are the result of recommendations of the Boulder dam controlling board, whose members are L. C. Hill, D. C. Henny, A. J. Wiley, F. L. Ransome and William F. Durand. The board, in a recent session at Denver, recommended a comprehensive study of cracks in dams which would include a theoretical analysis supplemented by field investigations.

## National Safety Code Proposed for Grandstands

A national safety code aimed to prevent the careless construction of grandstands, a serious menace to life in the season of sports and celebrations, will be undertaken at once by a national committee of engineers and construction experts under the leadership of the American Standards Association. This action follows the request for the establishment of such a code by the Pennsylvania Department of Labor and Industry and other organizations.

The code when completed will be used by state and municipal regulatory bodies, insurance companies and safety organizations. These bodies will be invited to appoint technical representatives to the committee which will prepare the code.

## *Personal Notes*

RALPH BUDD, president of the Great Northern Railway Co., will leave for Russia on June 1, having been invited by the Soviet government to make a survey of the railroads and advise the government in regard to rebuilding and extending its rail system.

GEORGE L. MINNISS has been appointed chief engineer of the Grade Crossing and Terminal Station Commission of the city of Buffalo, N. Y., to succeed the late George H. Norton. Mr. Minniss was formerly first assistant engineer and has been with the commission for the past fifteen years.

H. J. HARDER, city engineer of Paterson, N. J., has completed 30 years of service, having been appointed on May 10, 1900. Mr. Harder is the only survivor of those who were appointed to city office at that time.

C. C. HEZMALHALCH, deputy state engineer, has been elected president of the Colorado State Civil Service Employees Association. ROY RANDALL, engineering division, state highway department, has been elected second vice-president.

Major E. C. KELTON, formerly in charge of the Second Field Area, in the Memphis (Tenn.) engineering district, has been appointed head of the operations division by Lieut.-Col. F. B. Wilby, district engineer. He will succeed Major L. B. Chambers, transferred to Fort Lawton, Wash. Engineer FRANK I. LOUCKES, former assistant to Major Chambers, has been promoted to be assistant in charge of the Second Field Area, succeeding Major Kelton.

G. A. SLADE has recently entered the employ of Frank Lauza & Sons, Boston, Mass., and is engaged as engineer in federal-aid road construction in Massachusetts.

HARRY T. CAMPION has been employed by the city of Grand Rapids, Mich., to succeed Lloyd C. Billings as superintendent and chief chemist of the city filtration plant.

ALPHONSE LAFLECHE, formerly engineer of the River St. Lawrence ship channel, with headquarters at Ottawa, Ont., has been promoted to the position of assistant chief engineer.

JOHN N. EDY, who has been city manager of Berkeley, Calif., for the past seven years, has resigned, to take a similar position in Flint, Mich.

## *Obituary*

JOHN H. HOLL, of Canton, Ohio, a retired civil engineer, died on May 20. Mr. Holl, who was 80 years old, served for two years as county surveyor of Stark County and eight years as city engineer of Canton.

GEORGE WASHINGTON PATTERSON 3d, associate dean of the University of Michigan college of engineering, died on May 22 at the age of 66. Dean Patterson was educated at Yale, Massachusetts Institute of Technology, Harvard and the University of Munich, and had been on the Michigan teaching staff since 1889.

JAMES M. MCCARTHY, vice-president of Price Brothers & Co. and vice-president and treasurer of the American Freight & Traction Co., New York, died at his home in the city of Quebec on May 28. He was 66 years old. Mr. McCarthy, who was a graduate of McGill University, designed and built substructures of many bridges in Canada and the United States. After retirement from active engineering work, Mr. McCarthy assisted in developments on Ile Maligne and the Saguenay River.

ALBERT H. HOGELAND, consulting engineer of the Great Northern Railway, died at Rochester, Minn., on May 14, after an illness of two months. He was 72 years old. Mr. Hogeland had been with the Great Northern Railway for more than 51 years, and had actual charge of laying 2,500 miles of line for the road. Beginning as rodman in 1879, Mr. Hogeland was promoted to be maintenance engineer and went up step by step until he became chief engineer in 1903. He was in that position for ten years, when he became consulting engineer for one year, then chief engineer again from 1914 to 1925, and since that time he had been consulting engineer. He was a member of the American Society of Civil Engineers.

## *Society Calendar*

**AMERICAN SOCIETY FOR TESTING MATERIALS**, Philadelphia; annual meeting, Atlantic City, N. J., June 23-27.

**AMERICAN SOCIETY OF CIVIL ENGINEERS**, New York; annual convention, Cleveland, Ohio, July 9-11.

**AMERICAN WATER WORKS ASSOCIATION**, New York; annual meeting, St. Louis, Mo., June 2-6.

**NATIONAL SAFETY CONGRESS**, Chicago; annual meeting, Pittsburgh, Pa., Sept. 29-Oct. 3.

**SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION**, Pittsburgh, Pa.; 38th annual meeting, Montreal, Canada, June 26-28.

**WORLD POWER CONFERENCE**, second plenary meeting, Berlin, Germany, June 16-25. American secretary, O. C. Merrill, Washington, D. C.

**AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS** will meet at Minneapolis June 24-27.

**CENTRAL STATES SEWAGE WORKS ASSOCIATION** will hold its annual meeting at Springfield, Ill., June 9 and 10. Secretary, G. H. Radebaugh, Urbana, Ill.

**ENGINEERS CLUB** of Columbus, Ohio, held its annual meeting on May 22 and listened to an address by C. E. Grunsky, president of the American Engineering Council and past-president of the American Society of Civil Engineers. New officers were installed as follows: F. W. Jennings, president; J. R. Burkey, vice-president; C. D. McGuire, secretary-treasurer.

**ENGINEERS CLUB** of Ilion, N. Y., has elected the following officers: president, H. C. Andrus; vice-presidents, G. J. Shepherd and M. A. Snyder; treasurer, C. F. Pero; secretary, A. E. Theuerkauf.

**LOS ANGELES SECTION**, American Society of Civil Engineers, held a special meeting at the Engineers Club in that city on April 30 to meet J. F. Coleman, J. M. Howe and G. T. Seabury, president, vice-president and secretary, respectively, of the society, who were passing through Los Angeles en route from the spring meeting in Sacramento. Mr. Coleman spoke briefly on the Mississippi River flood-control problem, Mr. Howe on the progress and trend of the society and Mr. Seabury on plans for the society's development.

**MOHAWK VALLEY ENGINEERS CLUB** at a meeting in Utica on May 14 elected the following officers: president, Joseph Lamprecht, head of the civil engineering department of the Utica Gas & Electric Co.; first vice-president, W. F. McCann; second vice-president, W. C. Cahill; third vice-president, B. J. Babbitt; secretary, Walter F. Hudson. The club voted to retain its membership in the American Engineering Council.

**OHIO STATE UNIVERSITY CHAPTER**, American Society of Civil Engineers, at its annual meeting May 12 selected the following officers: president, William E. Burroughs; vice-president, Mark L. Allen; secretary-treasurer, John G. Goslin; Engineering Council representative, Robert Overman.

**PROFESSION ENGINEERS** of Oregon met in Corvallis in its second annual convention on May 23-24. Several papers were read, chiefly on sanitation and sewage treatment.

**ROCHESTER CHAPTER**, Society of Industrial Engineers, met on May 13, and listened to an illustrated address on "Industrial Marketing" given by Louis D. Waldron, Eastern district general manager of the McGraw-Hill Publishing Co.

**SMOKE PREVENTION ASSOCIATION** will hold its annual meeting at Newark, N. J., June 23 to 26. The secretary is Frank A. Chambers, Chicago.

# Construction Equipment and Materials

## Concrete Pavement Yardage

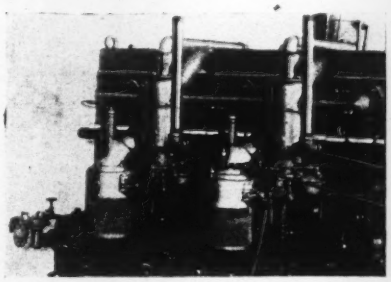
There is given below a tabulation of concrete pavement yardage awarded during the month of April, 1930, and also the total number of square yards awarded for roads, streets and alleys in the United States for the year 1930 to date as of May 3:

| | Sq.Yd. Awarded During April, 1930 | Sq.Yd. Awarded From Jan. 1, 1930 to May 3, 1930 |
|---|---|---|
| Roads | 14,337,642 | 36,233,037 |
| Streets | 3,968,828 | 8,923,718 |
| Alleys | 263,080 | 593,909 |
| Totals | 18,569,550 | 45,750,664 |

# New Developments

## Industrial Motors Equipped to Burn Heavy Fuels

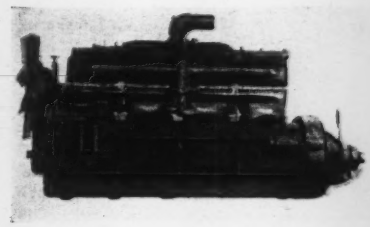
Utilization of low-cost distillate or gas-oil to obtain power and flexibility comparing favorably with gasoline-burning industrial engines of conventional design is now provided for in the Blue Streak line of engines as improved by the Climax Engineering Co., Clinton, Iowa. These models are produced in five sizes varying from 70 to 225 hp. in four-, six- and eight-cylinder models.



DUAL CARBURETOR INSTALLATION FOR LOW-GRADE FUEL

Equipment on the new motors is the same as that found on the gasoline-burning engine, with the addition of an oil rectifier, a heat-control mechanism and a water supply for full-load operation. To provide flexibility, heat supplied to the fuel mixture is varied automatically with the load by means of a rugged and simple mechanism consisting essentially of a sylphon bellows, an air valve and a water valve contained in an aluminum body attached to the carburetor air horn. Hot air is supplied through a flexible conduit connected to a box built around the exhaust manifold, equipped with an air cleaner. Unheated air is admitted to the mechanism through an additional air cleaner.

The sylphon is connected to the intake manifold by copper tubing so that pressure changes in the manifold caused by varying loads are transmitted to the sylphon, thus providing motive power to operate a valve regulating the supply of both heated and unheated air. This pressure-control device is similar to the spark-control mechanism used on Climax engines during the past two years. When power demands exceed three-quarters load, movement of the sylphon opens a valve which injects water into the intake manifold. This is pumped by an A-C fuel pump handling water instead of fuel. At full-load operation approximately 0.2 lb. of water per brake horsepower-hour is used. No water is used at less than three-quarters load capacity.



HEAVY-DUTY EIGHT-CYLINDER MOTOR

In starting the motor, gasoline is used until the engine is thoroughly warmed up, when a change is made to the heavier fuel. Special Zenith carburetors are used, the smaller engines requiring only one, whereas the larger models are equipped with dual installations.

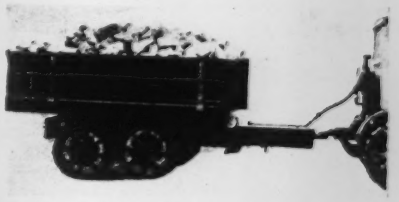
A recent addition to the Blue Streak series is the model R-8-1, which develops more than 200 hp. at 1,000 r.p.m. and 225 hp. at 1,200. This engine has 6x7-in. cylinders and burns gasoline, distillate or natural gas as a fuel. It is equipped with two Zenith carburetors, dual ignition, three oil pumps for force-feed lubrication, two Leece-Neville starting motors, a governor and magneto ignition. Cooling is cared for by a large centrifugal water pump and by a 36-in. eight-bladed fan with triple V-belt drive. All oil is passed through a duplex oil filter.

## New Explosive Developed

A new type of explosive now being marketed under the name of Gelamite is announced by the Hercules Powder Co., Wilmington, Del., as the result of extensive experimental work to obtain an explosive that will do work ordinarily requiring gelatin dynamite at a considerable reduction in blasting costs. The new explosive combines the safety and economy features of the high-ammonia content dynamites with the more water-resistant characteristics of gelatin, at the same time being semi-plastic and easy to handle. It is adaptable to either open or underground shooting. Three strengths are available, replacing the old style gelatins and extra gelatins of 30 to 60 per cent strengths.

## Crawlers Carry Three-Way and Bottom-Dump Wagons

New models of dirt-moving equipment recently announced by the LaPlant-Choate Manufacturing Co., Inc., Cedar Rapids, Iowa, include a three-way dump wagon of 7-8 cu.yd. capacity and a 6-cu.yd. bottom dump wagon. Both of these are designed for use with tractors, are equipped with rigid-type crawler treads and are dumped by hydraulic hoists. The bottom-dump wagon can also be obtained with hand winding mechanism. The road-layer tracks used are built under patents belonging to the Caterpillar Tractor Co. and are of the rigid type which resist upward pressure and still enable the track to follow around the wheels with a minimum of friction. Each link is made of one steel casting and is tied to its neighbors by large hardened steel pins fitting in removable hardened steel bushings. The design of the track is such that it is almost impossible for small rocks to fall down inside of the link; however, as an added precaution, apron shields and mudguards are fastened on each side of the track assembly. The wheels are mounted on heat-treated and hardened steel axles, utilizing Hyatt heavy-duty bearings with ground inner and outer races. Proper lubrication is provided for by large grease reservoirs and openings through which the grease travels to the working parts. The hubs are made greasetight and oilproof by means of spring tension cork seals. All parts are greased at one time by removing the plug in the end of the wheel axle and attaching a pressure gun.



HYDRAULIC CONTROL WAGON DUMPS TO EITHER SIDE OR REAR

The body of the three-way dump wagon is built by Differential Steel Car Co., Findlay, Ohio, and is equipped with hydraulically operated dowafolding doors at the sides. The rear door can be hinged either at top or bottom, and a chain may be attached for spreading earth when desired. The body itself is made of ¼-in. steel, with the bottom constructed of double ¼-in. plates between which is placed a cushion of 2-in. seasoned wood. The single hydraulic

hoisting unit has ball-and-socket joints at both the top and the bottom. A relief pressure valve permits oil to bypass when the body reaches full height, eliminating any chance of breakage due to overpressure. For side dumping, the maximum angle is 48 deg.; for rear dumping, 50 deg. The approximate weight of the wagon is 17,200 lb. It is equipped so that it may be operated singly or in trains of two or more.

Construction of the 6-yd. bottom-dump wagon is similar, with an all-steel body of ¼-in. plate and the same type of track. One-piece box construction is used in the tongue, which is made of extra-heavy steel plates and channels electrically welded. A case-hardened removable bushing, through which the drawbar operates, is pressed into the tongue. Design of the wagon, which has a water level capacity of 5.3 cu.yd., is similar to that of larger units already described in *Engineering News-Record*, May 23, 1929, p. 851. The approximate weight of the 6-cu.yd. wagon is 8,850 lb.

## Hoist Eliminated on Cone-Shaped Concrete Carrier Body

Ready-mixed concrete can be dumped by gravity without the use of a hoist, from the conical body developed by Parke Concrete Carriers, Inc., New York City, in sizes up to 5 cu.yd. This

CONE-SHAPED CONCRETE BODY DISCHARGES BY GRAVITY

body, which is smooth on the inside without baffles or mixing blades, is revolved while in transit either by a separate motor or by a power take-off from the truck transmission. It is fitted with a single large door in the rear, through which the mixed concrete is loaded at the mixer and discharged at the job. Full discharge of all material is secured by rocking the body slightly to and fro with the door open. This same rocking action can be utilized to discharge the load into wheelbarrows, when necessary, without excess spillage and waste. Advantages claimed for this type of body include lighter weight, due to the elimination of the hoist; ability to dump where headroom is limited; ease in cleaning, because of the absence of baffles; and a reduction in body shocks, due to the wedging action at the small end of the cone when the truck is stopped suddenly. In addition, it is stated that the truck can be operated in any weather as, once the charging door is closed, rain or snow cannot penetrate to the interior of the body. The carrier can be fitted to any standard make of motor truck of the proper size.

## Business Notes

STEEL FOUNDERS' SOCIETY OF AMERICA, INC., New York City, has recently adopted and issued a standard sales agreement, order acceptance, quotation sheet, and a set of standard trade customs for that industry. The purpose is to clarify and simplify the many questions arising between buyers and sellers in order to give a more equitable understanding of contractual relations.

NATIONAL COMMITTEE OF WOOD UTILIZATION, Washington, D. C., has appointed E. Mark Ferree a member of its staff. Mr. Ferree was formerly connected with the Southern Pine Association, New Orleans, La. He will be chiefly occupied with the promotion of committee projects in the consumer field.

OHIO STEEL FOUNDRY CO., of Lima and Springfield, Ohio, has purchased the steel foundry department and steel-casting business of the Industrial Brownhoist Corp. at Bay City, Mich.

AMERICAN ROLLING MILL CO., Middletown, Ohio, has effected a combination with the Sheffield Steel Corp., East Kansas City, Mo., which will add approximately 200,000 tons annually to its production. This action represents the adoption of a new diversification policy by the American Rolling Mill Co.

CAROLINA WOOD PRESERVING CO. has acquired the Charleston (S. C.) plant of J. F. Prettyman & Sons. Thomas J. Thorne, formerly manager of the Prettyman plant, is vice-president and general manager of the Carolina company. Other officers include: Grant B. Shipley, president; E. S. Park, vice-president; and H. W. Wehe, secretary-treasurer.

BROWN CLUTCH CO., Sandusky, Ohio, has appointed W. J. Savage manager of sales. Mr. Savage was formerly affiliated with the Heltzel Steel Form & Iron Co., Warren, Ohio, as sales and advertising manager.

JEFFREY MANUFACTURING CO., Columbus, Ohio, has elected J. Frank Davidson, assistant general manager, to the position of vice-president.

FERROUS MAGNETIC CORP., New York City, has been formed to act as an independent organization for research in the iron and steel industry. It will conduct research on its own account and will also co-operate with existing firms in designing, building and leasing production magnetic equipment for inspection purposes.

ANACONDA WIRE & CABLE COMPANY OF CALIFORNIA, a subsidiary of Anaconda Wire & Cable Co., New York City, has purchased the assets of the California Wire & Cable Co., with plants at Orange and Oakland. These mills will be in charge of Louis Koth, manager. Sales on the Pacific Coast will continue to be supervised by W. E. Sprackling, vice-president in charge of sales, with headquarters in New York City.

LINCOLN ELECTRIC CO., Cleveland, Ohio, announces the advancement of Harold F. Kneen to the position of plant superintendent.

AUGUST C. FRUEHAUF, chairman of the board of directors of the Fruehauf Trailer Co., Detroit, Mich., died on May 11. Born in Fraser, Mich., in 1868, Mr. Fruehauf has been prominently identified with the transportation field for more than 35 years. In 1914 he designed and built what is believed to be the first semi-trailer made in this country for use in connection with a light motor truck. Since that time he has been prominent in the development of this type of vehicle for use in many diversified lines of business.

## Costs and Contracts

### E. N.-R. Index Numbers

| Cost | | | Volume | | |
|---|---|---|---|---|---|
| May 1, | 1930 | 205.86 | April, | 1930 | 351 |
| Apr. 1, | 1930 | 207.12 | March, | 1930 | 408 |
| May 1, | 1929 | 205.15 | April, | 1929 | 332 |
| Average, | 1929 | 207.02 | Average, | 1929 | 317 |
| Average, | 1928 | 206.78 | Average, | 1928 | 287 |
| 1913 | ..... | 100.00 | 1913 | ..... | 100 |

### This Week's Contracts

Heavy construction contracts, reported by *Engineering News-Record* in the week of May 29, with some comparisons, total as follows:

(In Thousands of Dollars)

| | May 29, 1930 | Average Preceding Four Weeks 1930 | Preceding Four Weeks 1929 |
|---|---|---|---|
| Buildings: | | | |
| Industrial .... | $4,972 | $14,713 | $14,327 |
| Other ..... | 15,024 | 35,674 | 50,810 |
| Streets and roads. | 13,538 | 17,364 | 17,121 |
| Other eng. constr. | 46,812 | 21,225 | 22,412 |
| Total ..... | $80,346 | $88,977 | $104,672 |
| Total, all classes, Jan. 1 to May 29: | | | |
| 1930 ..... | | | $1,567,800 |
| 1929 ..... | | | 1,909,760 |

## New Publications

*Pumps*—"Successful Canadian Pumping Stations" are illustrated, described and listed in a 28-p. leaflet issued by the DELAVAL STEAM TURBINE CO., Trenton, N. J.

*Steel Properties*—Approximate relations between Brinell, Rockwell and Shore hardnesses and the tensile strengths of structural alloy steels are given in chart and tabular form in a 4-p. bulletin of the INTERNATIONAL NICKEL CO., INC., New York City.

*Tractor Equipment*—Side boom units, crushers, bulldozers and other auxiliaries for use with Caterpillar and McCormick-Deering tractors are described in a new catalog of the W-K-M Co., INC., Houston, Tex.

*Surfacing Metal*—"Haynes Stellite Products in the Oil Fields," a 32-p. illustrated booklet, is the fourth of a series issued by the HAYNES STELLITE CO., Kokomo, Ind., describing the uses and methods of application of its products.

*Ash Removal*—A 4-p. leaflet on the Nuveyor pneumatic ash conveyor, applicable to power plants handling from 5 to 100 tons of ashes per day, may be obtained from the UNITED CONVEYOR CORP., Chicago, Ill.

*Contractors' Equipment*—A new catalog covering practically the entire line of equipment produced by the HELTZEL STEEL FORM & IRON CO., Warren, Ohio, is now being distributed. The products described include forms, batchers, steel bins, utility bridges, mixing boxes and many others.

*Sewage Disposal*—Bulletin 101, issued by the STROUDSBURG SEPTIC TANK CO., Stroudsburg, Pa., gives a complete description of all products of the company and includes information on the installation of proper sewage-disposal equipment to care for needs varying from that of a single residence to industrial villages and manufacturing plants. The bulletin contains 24 pages and is well illustrated.

*Weighing Apparatus*—In celebration of the centennial anniversary of the invention of the platform scale by Thaddeus Fairbanks, FAIRBANKS, MORSE & CO., Chicago, Ill., has issued a 20-p. booklet, illustrated in color, which gives the history of the development of weighing machines and tells something of the accomplishments, aims and aspirations of the company. It is entitled "Beginning the Second Century."

*Safety*—Methods of preparing and displaying safety advertising material to obtain co-operation from the man on the job are given in "Safety Advertising," a 15-p. booklet issued by the Policyholders Service Bureau of the METROPOLITAN LIFE INSURANCE CO., New York City. The publication discusses the principles, form, appeal and media to be used in this type of publicity and is illustrated with photographs of effective bulletin board and blackboard displays.

*Centrifugal Pumps*—Effective methods used for priming centrifugal pumps manually are illustrated and described in a series of bulletins bound together in loose-leaf form which may be obtained from BARRETT, HAENTJENS & CO., Hazleton, Pa. The subjects discussed in clear and non-technical language include the theory of priming, submerged pumps, the use of foot valves, air, steam and water ejectors, hand- and motor-operated priming pumps and the arrangement of intake piping.

# Unit Prices From Current Construction Bids

## Open and Unlined Canal in New Orleans

CONTRACT 206-D is for an open and unlined canal in Algiers (New Orleans) between pumping stations 8 and 9. The work includes building a small earth embankment and the disposal of surplus material, building necessary bridges, pipe lines and culverts, and replacement of pavement. John L. McWilliams is doing the work. His bid of $48,265 was 20 per cent below the second bidder, the New Construction Co., Echo, La. Excavation, including backfilling and grading, amounts to 65 per cent of the total cost, and for this element the two contractors (see tabulation) bid 10.45c. and 11.85c. respectively, compared with the four other bids of 18.94c., 20.3c., 23c. and 26c. The second large item is overhaul, paid for as follows: 500-1,000 ft. from center line of canal, one overhaul; 1,000-1,500, two overhauls, and so on. (A) John L. McWilliams. (B) New Construction Co.

| | A | | B | |
|---|---|---|---|---|
| | Price | Amount | Price | Amount |
| Excavation, including backfilling, grading, etc., 300,000 cu.yd. | $0.1045 | $31,350 | $0.1185 | $35,550 |
| Overhaul cu.yd. per 500 ft. in excess of 500 ft., 50,000 cu.yd. | 0.09 | 4,500 | 0.20 | 10,000 |
| Brickwork, 50 cu.yd. | 23.00 | 1,150 | 25.00 | 1,250 |
| Yellow pine creosoted piling driven (piles about 30 ft. long), 3,000 lin.ft. | 1.00 | 3,000 | 1.10 | 3,300 |
| Yellow pine capping furnished in place, ft. b.m. per M., 5,000 ft. b.m. | 95.00 | 475 | 0.80 | 4,000 |
| Y. P. lumber for bridges, etc., including bolts, etc., 60 M.b.m. | 85.00 | 5,100 | 75.00 | 4,500 |
| | | $48,265 | | $60,595 |

## Cast-Iron and Corrugated Pipe in Maryland

EIGHT state highway projects in Maryland totaling 37.02 miles (bids March 26) included considerable cast-iron and corrugated-metal pipe. The lowest two bids for each size and the weighted average of all bids (2 to 8) are tabulated below:

| Cast-Iron, Inch | 1 | 2 | Weighted Average |
|---|---|---|---|
| 15 | $2.50 | $2.50 | $2.75 |
| 18 | 3.50 | 4.00 | 4.02 |
| 24 | 4.75 | 5.00 | 5.18 |
| 30 | 8.00 | | 8.00 |
| 36 | 8.50 | 9.00 | 8.84 |
| **Corrugated-Metal, Inch** | | | |
| 12 | 1.65 | 1.80 | 1.75 |
| 14 | 1.90 | 2.00 | 1.99 |
| 16 | 2.25 | 2.25 | 2.27 |
| 30 | 4.50 | 5.50 | 5.00 |
| 36 | 5.50 | 6.00 | 5.75 |
| 42 | 6.50 | 6.50 | 6.86 |
| 48 | 7.00 | 8.00 | 7.50 |

## $4,788,737 Subway in Brooklyn, Under Elevated Railway

BIDS were received Feb. 4, 1930, by the New York Board of Transportation for the construction (covered trench method) of Sec. 4 of Route 110, under Fulton St. from Lewis Ave. to McDougal St., Brooklyn.

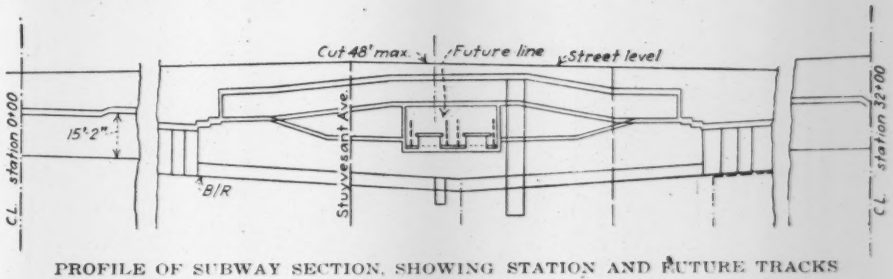
Eleven contractors, all of New York, submitted bids, with a spread of 16 per cent, and a difference between low and average of 6 per cent. Time of completion is 35 months; railroad is to be in condition for track and signal installation and station finish in 29 months. The contractor must finance the work for three months before he receives the first payment on the contract. During construction of the subway section the elevated railway on Fulton St. must be maintained in safe condition for continuous operation. This necessitates the support of 134 elevated columns at a cost of about $4,000 each, which accounts for nearly 10 per cent of the contract price. The accompanying unit prices on a number of the more important items include the support of these columns, but omit the nearly half million dollars' worth of demolition and underpinning. In connection with unit prices a paragraph in italics in the specifications reads: "The unit prices must not be improperly balanced, and any bid which the board considers detrimental to the city's interest may be rejected."

A third of the estimated cost of the work is for 370,000 cu.yd. of earth excavation. The price includes cost of disposal of excavated material, ramps, backfilling, filling and compacting spaces under station platforms, filling basements, cellars and vaults, sheeting and bracing, maintaining and supporting trenches, and all support and protection not specifically provided for in the list of unit prices.

Next to excavation the largest items were 46,000 cu.yd. concrete masonry and 7,700 tons fabricated steel. There is also an item of 450 tons of steel rods, bars, anchors and dowels in place in concrete, and the price includes bending and cutting, bracing during pouring, and all drilling and grouting in connection with placing the dowels. The price, as well as the price of the fabricated structural steel, includes furnishing, delivering, erecting, cleaning and painting.

This is a four-track section on one level, and includes a station at Stuyvesant Ave. At the station site provision is made for a future four-track subway line crossing above this section at nearly right angles. Depth of excavation varies from 27 to 48 ft., the maximum being at the station.

| | A | B | C |
|---|---|---|---|
| Earth excavation, 370,000 cu.yd. | $4.07 | $3.35 | $3.60 |
| Concrete, 28,000 cu.yd. | 17.00 | 16.50 | 16.00 |
| Protective concrete, 4,200 cu.yd. | 17.00 | 16.50 | 16.00 |
| Finished surface, 170,000 sq.ft. | 0.08 | 0.10 | 0.10 |
| Fabricated steel, 7,700 tons | 100.00 | 95.00 | 100.00 |
| Reinforcing, 450 tons | 92.00 | 85.00 | 90.00 |
| Special wire forms, 12,000 lb. | 0.35 | 0.15 | 0.20 |
| Waterproofing, 1-ply, 6,700 sq.yd. | 0.95 | 0.85 | 0.50 |
| Waterproofing, 3-ply, 31,000 sq.yd. | 2.10 | 1.80 | 2.25 |
| Tunnel ducts, 135,000 duct-ft. | 0.23 | 0.25 | 0.25 |
| Railroad ducts, 66,000 duct-ft. | 0.40 | 0.35 | 0.40 |
| 3-in. std. galv. steel pipe, 3,000 ft. | 2.15 | 1.00 | 1.00 |
| 4-in. std. galv. steel pipe, 3,500 ft. | 2.50 | 1.25 | 2.50 |
| 15-in. vit. pipe sewer, 1,200 ft. | 5.50 | 7.50 | 8.00 |
| 18-in. vit. pipe sewer, 1,000 ft. | 6.00 | 9.00 | 9.00 |
| 2-in. steel elec. conduits, 15,000 ft. | 0.40 | 0.35 | 0.30 |
| 1-in. steel elec. conduits, 6,500 ft. | 0.50 | 0.40 | 0.40 |
| Steel ventilation gratings, 6,600 sq.ft. | 2.25 | 2.00 | 2.00 |
| Repaving roadway, asphalt, 12,000 sq.yd. | 3.00 | 3.50 | 3.50 |
| Repaving roadway, granite blk., 5,500 sq.yd. | 3.50 | 4.00 | 3.50 |
| Sidewalk restoration, 9,500 sq.yd. | 2.25 | 2.50 | 3.25 |
| New curb, 5-in. bluestone, 2,000 ft. | 2.25 | 2.00 | 3.00 |
| Old curb, 5-in. bluestone, 4,500 ft. | 0.90 | 1.00 | 2.00 |
| Support and reconstruct. elec. ry., 6,900 ft. single track | 4.75 | 8.00 | 5.00 |
| Support elev. columns on structure, 132 cols. (each) | 3,720.00 | 4,865.00 | 5,300.00 |
| Support elev. columns off structure, 2 cols. (each) | 3,380.00 | 4,865.00 | 5,300.00 |
| 6-in. steel bypass pipe on or below street, 7,000 ft. | 4.00 | 5.00 | 5.00 |
| 12-in. steel bypass pipe on or below street, 3,000 ft. | 5.00 | 8.25 | 9.00 |
| Vit. elec. ducts on conduits, 90,000 duct-ft. | 0.35 | 0.35 | 0.48 |
| 3-in. wood elec. ducts, 5,000 ft. | 0.30 | 0.35 | 0.40 |
| 3-in. fiber elec. ducts, 4,000 ft. | 0.35 | 0.35 | 0.40 |
| 3½-in. fiber elec. ducts, 14,500 ft. | 0.35 | 0.35 | 0.40 |
| | $4,788,737 | $4,792,180 | $4,949,497 |




PROFILE OF SUBWAY SECTION, SHOWING STATION AND FUTURE TRACKS

# Unit Prices From Current Construction Bids

## Allegheny Boulevard, Pittsburgh

ALLEGHENY County River Boulevard project Contract 3 (bids Feb. 25, 1930) extends from the Washington Boulevard in Pittsburgh to the intersection of James and Front Sts. in Verona Borough. This boulevard, following the cliffs along the riverbank, will shorten by 3½ miles the distance to Pittsburgh for 70,000 residents of upper Allegheny Valley. The Conemaugh division of the Pennsylvania Railroad lies between the river and the new boulevard, which will have a reinforced-concrete wearing surface 30 to 40 ft. wide and 25,555 ft. long. The special construction features include the following (designated by number on the accompanying map):

1. Concrete highway underpass at the Brilliant cut-off tracks of the Pennsylvania.
2. Concrete highway underpass at Pennsylvania tracks connecting East Liberty station with the Conemaugh division.
3. Combination culvert and railroad underpass for a switch Y of the Pennsylvania.
4. Sandy Creek culvert.
5. Quigleys Run culvert.

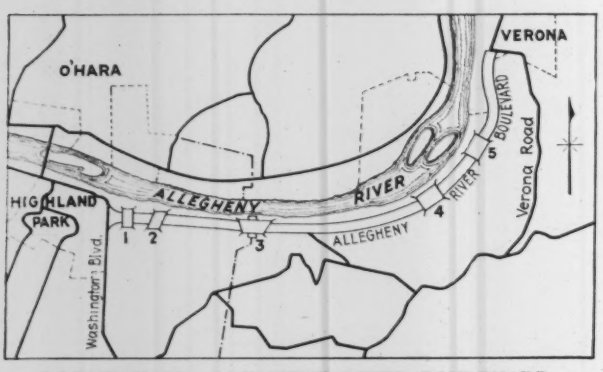
The contract price is $1,984,807, and the largest items are 93,000 cu.yd. of excavation at 75c. and 84,600 sq.yd. paving at $3.15.

Item 1 includes disposal of unsuitable material, backfilling and foundation of embankments. Where rolling is impracticable, mechanical tamping may be directed. Bids varied between 75c. and $1.25.

Class A (1:2:4) concrete is specified for shoulders, gutters and aprons, sidewalks and base course; Class C (1:2:3½) for pavement.

The lowest three bidders are: (A) John F. Casey Co., Aspinwall, (awarded contract); (B) Vang Construction Co., Grant Blvd.; (C) A. Guthrie & Co., Inc., St. Paul.

| | | | A | B | C |
|---|---|---|---|---|---|
| Excav. | Cu.Yd. | 930,000 | $0.75 | $0.79 | $1.10 |
| Foundation excav. | Cu.Yd. | 2,200 | 2.15 | 2.50 | 3.00 |
| Slag in embankment (granulated) | Cu.Yd. | 7,200 | 1.50 | 1.30 | 1.00 |
| Plain Class A conc. in retaining walls and footers | Cu.Yd. | 2,000 | 14.50 | 14.00 | 16.00 |
| Steel reinforcement (bars) | Lb. | 50,000 | .045 | .04 | .05 |
| 15 in. rein. conc. pipe culverts | Lin.Ft. | 6,500 | 3.00 | 2.75 | 2.00 |
| 18 in. rein. conc. pipe culverts | Lin.Ft. | 2,700 | 3.60 | 3.50 | 2.50 |
| 24 in. rein. conc. pipe culverts | Lin.Ft. | 1,200 | 4.55 | 5.00 | 4.00 |
| 30 in. rein. conc. pipe culverts | Lin.Ft. | 350 | 5.85 | 7.00 | 5.00 |
| 72 in. rein. conc. pipe culverts | Lin.Ft. | 630 | 28.50 | 26.00 | 45.00 |
| 8 in. cast-iron pipe culverts | Lin.Ft. | 200 | 3.00 | 2.50 | 2.00 |
| Plain class A conc. paved shoulders | Sq.Yd. | 3,000 | 2.15 | 2.25 | 2.65 |
| Broken stone and 6 in. T.C. pipe sub-drain | Lin.Ft. | 1,000 | 1.50 | 1.00 | 1.10 |
| Broken stone subdrain | Lin.Ft. | 1,000 | 1.00 | .80 | .85 |




LOCATION OF ALLEGHENY RIVER BOULEVARD
Numbers refer to structures listed in the text.

| | | | | | |
|---|---|---|---|---|---|
| Plain class A conc. gutter aprons | Sq.Yd. | 1,200 | 2.60 | 2.25 | 2.95 |
| Special ditch | Cu.Yd. | 4,500 | 2.25 | 2.00 | 1.00 |
| Stone underdrains | Lin.Ft. | 12,000 | .63 | .70 | .40 |
| Storm inlets, types I and I-A | | 130 | 100.00 | 120.00 | 125.00 |
| Brick manholes | | 6 | 175.00 | 150.00 | 125.00 |
| Special brick manholes | | 2 | 225.00 | 600.00 | 1,125.00 |
| Broken stone sub-base | Cu.Yd. | 6,000 | 2.00 | 3.00 | 4.25 |
| Plain class A conc. in base course (9 in.) | Sq.Yd. | 4,800 | 3.15 | 2.80 | 2.65 |
| Asphaltic conc. wearing surface (2 in.) | Sq.Yd. | 4,300 | 1.80 | 2.00 | 1.50 |
| Rein. class C conc. pavement (10x8x10 in.) | Sq.Yd. | 84,600 | 3.15 | 3.10 | 3.20 |
| Gran. slag pavement (12 in.) | Sq.Yd. | 1,500 | .71 | .60 | .70 |
| Flagstone pavement | Sq.Yd. | 600 | 4.00 | 4.00 | 5.50 |
| Plain class A conc. dr'w'y aprons (8 in.) | Sq.Yd | 200 | 3.45 | 2.50 | 4.00 |
| Sandstone curb with broken stone drain | Lin.Ft. | 600 | 1.95 | 2.00 | 2.15 |
| Granite curb with broken stone drain | Lin.Ft. | 26,200 | 2.88 | 2.75 | 2.85 |
| Granite curb with broken stone and 6 in. T.C. pipe drain | Lin.Ft. | 21,700 | 3.12 | 3.00 | 3.00 |
| Granite radius curb with br'kn stone drain | Lin.Ft. | 850 | 3.80 | 3.00 | 3.50 |
| Granite radius curb with broken stone and 6 in. T.C. pipe drain | Lin.Ft. | 150 | 4.05 | 4.00 | 3.60 |
| Wood post barrier (1 in. top wire—¾ in. bottom wire) | Lin.Ft. | 23,200 | .76 | 1.00 | .80 |
| Class A conc. sidewalk | Sq.Ft. | 10,000 | .24 | .30 | .27 |
| Gran'lt'd slag sidewalk | Sq.Ft. | 150,000 | .10 | .05 | .06 |
| Iron pipe railing with screen guard | Sq.Ft. | 250 | 4.00 | 4.00 | 2.75 |
| Special plain class A conc. gutter | Sq.Yd. | 3,000 | 4.70 | 2.50 | 4.25 |
| Special plain class A conc. berm. gutter | Sq.Yd. | 2,500 | 2.85 | 2.50 | 3.20 |
| Special stone paved gutter set in cement mortar bed | Sq.Yd. | 2,000 | 3.40 | 2.50 | 2.65 |
| 1 in. galv. iron pipe | Lin.Ft. | 4,000 | .50 | .30 | .25 |
| 2 in. galv. iron pipe | Lin.Ft. | 4,000 | .75 | .60 | .50 |
| Pipe fittings | Lb. | 1,000 | .20 | .20 | .75 |
| 6 in. T.C. pipe drains, cemented joints | Lin.Ft. | 2,000 | 1.00 | 1.00 | .30 |
| *Trees and Grass* | | | | | |
| Oriental plane trees | | 1,500 | 3.25 | 3.10 | 6.12 |
| Chinese elm trees | | 15 | 4.00 | 4.00 | 4.53 |
| Thicket hawthorne trees | | 200 | 3.25 | 3.30 | 4.10 |
| Tree of Heaven | | 300 | 3.25 | 3.30 | 4.53 |
| Barberry shrubs | | 1,500 | .45 | .40 | .72 |
| Hybrid golden bell | | 100 | .55 | .60 | .93 |
| Dark green golden bell | | 100 | .55 | .60 | .93 |
| Drooping golden bell | | 1,500 | .55 | .50 | .93 |
| Regels privet | | 500 | .55 | .50 | .88 |
| English privet | | 1,000 | .55 | .50 | .77 |
| Prairie rose | | 1,000 | .65 | .65 | .83 |
| Shining sumac | | 400 | .80 | .80 | 1.08 |
| Fragrant sumac | | 400 | .80 | .80 | 1.25 |
| Staghorn sumac | | 400 | .80 | .70 | 1.15 |
| Silky dogwood | | 300 | .55 | .50 | .82 |
| Rose weigela | | 200 | .55 | .50 | .78 |
| Japanese bittersweet | | 2,500 | .55 | .50 | .82 |
| English ivy | | 50 | .75 | .70 | 1.03 |
| Boston ivy | | 50 | .75 | .70 | .82 |
| Grass seeding | Sq.Ft. | 150,000 | .01 | .01 | .014 |
| Top soil | Cu.Yd. | 8,000 | 2.25 | 2.50 | 2.66 |
| *Bridge Construction Items* | | | | | |
| Excav. for fnd. below El. 725, incl. removal of existing masonry | Cu.Yd. | 2,400 | 3.00 | 6.00 | 5.00 |
| Excav., etc., for fnd. above El. 725 | Cu.Yd. | 26,000 | 2.00 | 2.70 | 2.50 |
| Excav. for channel chg. | Cu.Yd. | 600 | 1.00 | 3.00 | 1.10 |
| Conc. in fnd. except toe walls | Cu.Yd. | 8,800 | 12.30 | 12.00 | 15.00 |
| Conc. in toe walls | Cu.Yd. | 900 | 18.00 | 14.00 | 15.00 |
| Rein. conc. above fnd. and all conc. in cantilever retain. walls except toe walls | Cu.Yd. | 8,200 | 17.50 | 22.00 | 18.00 |
| Plain conc. above fnd. in abutments and wing walls | Cu.Yd. | 6,200 | 15.45 | 13.00 | 15.00 |
| Premolded conc. piles | Lin.Ft. | 7,000 | 2.85 | 2.80 | 2.50 |
| Tar waterproofing | Sq.Yd. | 6,000 | .90 | .35 | .90 |
| Stone drains | Cu.Yd. | 1,700 | 5.00 | 4.00 | 5.00 |
| Extra portland cement | Bbl. | 1,000 | 2.25 | 2.10 | 2.25 |
| Admixtures | Cu.Yd. of conc. | 28,000 | .30 | .22 | .50 |
| Steel reinforcing and dowels | Lb. | 900,000 | .05 | .04 | .04 |
| Struc. steel and anchor bolts | Lb. | 4,500 | .10 | .12 | .10 |
| Maintaining traffic on Penn R.R. | | | $2,500.00 | $12,000.00 | $10,000.00 |
| Removal of superstructure of existing bridges at Sandy Creek and Quigleys Run | | | 1,500.00 | 1,700.00 | 1,000.00 |
| Membrane waterproofing | Sq.Yd. | 3,000 | 1.50 | 2.50 | 3.25 |
| Totals | | | $1,984,807 | $2,048,890 | $2,401,152 |